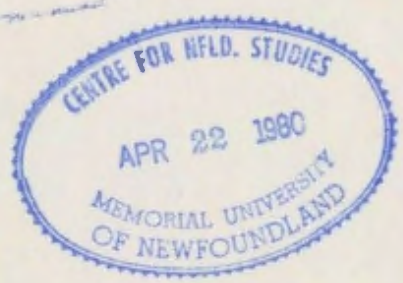
THE DEVELOPMENT OF AN INSTRUCTIONAL PACKAGE, FOR THE GRADE X CREDIT PHYSICAL EDUCATION PROGRAMME, ENTITLED "MEASURING FITNESS"

COLIN HIGGS


CENTRE FOR NFLD. STUDIES
APR 22 1980
MEMORIAL UNIVERSITY
OF NEWFOUNDLAND

NOTICE

The quality of this microfiche is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us a poor photocopy.

Previously copyrighted materials (journal articles, published tests, etc.) are not filmed.

Reproduction in full or in part of this film is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30. Please read the authorization forms which accompany this thesis.

THIS DISSERTATION HAS BEEN MICROFILMED EXACTLY AS RECEIVED

AVIS

La qualité de cette microfiche dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de mauvaise qualité.

Les documents qui font déjà l'objet d'un droit d'auteur (articles de revue, examens publiés, etc.) ne sont pas microfilmés.

La reproduction, même partielle, de ce microfilm est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30. Veuillez prendre connaissance des formules d'autorisation qui accompagnent cette thèse.

LA THÈSE A ÉTÉ MICROFILMÉE TELLE QUE NOUS L'AVONS REÇUE

THE DEVELOPMENT OF AN INSTRUCTIONAL PACKAGE, FOR THE GRADE X CREDIT PHYSICAL EDUCATION PROGRAMME, ENTITLED "MEASURING FITNESS"

by

©Colin Higgs, B.Sc., M.Sc.

A Thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Education

Faculty of Education,
Division of Learning Resources,
Memorial University of Newfoundland

January 1979

St. John's Newfoundland

ABSTRACT

Using an instructional development model, an instructional package was developed for use in the Province of Newfoundland's Grade X credit physical education programme. A survey of teachers indicated that the subject areas;

i. Measurement of fitness.

ii. Maximum oxygen uptake test.

were considered most needing of additional instructional materials. A further survey indicated that the preferred instructional media was a student booklet.

The booklet was produced and refined through a process of formative evaluation in which changes were suggested by content, learner and media experts, and by a sample of learners.

A summative evaluation was undertaken using a two group design in which group A undertook a pre-test studied the material and then took a post-test, while group B studied the material and then

took the post-test. Basic biographical data was collected from both groups.

The results indicated that by virtue of the instructional package learning occurred to a significant degree and that post-test scores were not affected to a significant degree by exposure to the pre-test or by the student's previous or concurrent exposure to high school biology.

It was concluded that the instructional package met the pre-determined criterion of acceptable performance in that greater than 80% of the sample achieved success on 80% or more of the stated behavioral objectives.

Acknowledgements

I would like to take this opportunity to thank all of those people who helped make this study possible. For their help during the production of the booklet my special thanks to Mr. J. Saunders, Mr. H. Roach and Mr. M. Wells - many of their suggestions were incorporated in the text; but I, not they, am responsible for any errors of omission or commission which remain.

My thanks also to the faculty and students of the Division of Learning Resources, Memorial University of Newfoundland, for their support and to all of the students who acted as subjects.

Lastly my thanks to Mavis, without whom this would not have been completed.

Colin Higgs

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

List of Tables

List of Figures

CHAPTER I

BACKGROUND TO THE PROBLEM

Of all subjects included in the curriculum of Newfoundland's schools only physical and religious education are required by law (Government of Newfoundland 1968). This can be seen as an indication of the importance of these subjects in the eyes of the Province's legislators.

Historically, within the schools of Newfoundland, physical education has been a recreational, non-credit, activity to which the pupils were exposed relatively infrequently at the higher grade levels.

However, this state of affairs was altered in 1973 when some concerned physical education teachers approached the Department of Education to see if it was possible to launch a credit programme in physical education at the high school level, specifically in Grade X. The Department was cooperative and in 1974 the first pilot project was started in the St. John's area.

The Grade X pilot project was designed to cover both practical and theoretical aspects of physical education with a time allocation of four periods of forty minutes

per week. The time was divided as follows:

25% Applied physiology

75% Practical activities.

During the first three years of the pilot programme, a student manual was written by the Department of Education in conjunction with involved teachers (Saunders, 1976)

In 1977 this manual was mass produced and was distributed to each of the 14 schools involved in the Grade X programme and also to the 7 schools involved in the more recently inaugurated Grade XI programme.

Rapid expansion of the number of schools and pupils involved in the programme occurred in 1978 and initial responses show that for 1979 there will probably be an even greater rate of expansion. This year, 1978, pupils will write Grade XI public examinations in the subject for the first time. Hope has been expressed that by 1982 physical education will be a compulsory credit programme[1].

Mr J. Saunders, Physical Education Consultant for the Provincial Department of Education, and one of the people most concerned with the introduction of the credit programme and the writing of the course manual has stated[1]

---

[1] Private conversation with Mr. J. Saunders, Physical Education Consultant, Province of Newfoundland, held fall 1978.

that the biggest handicap to the credit programme has been the lack of suitable material in the realm of applied physiology.

Within this general area more specific subject matter has been singled out as being particularly lacking, the single most pressing being that of the conceptualization of the theory of physical fitness testing, the testing of fitness and the interpretation of test scores.

Needs Assessment

With the greatest perceived need seen as being in the area of physical fitness testing, with special emphasis on the conceptualization of the theory underlying cardio-vascular respiratory fitness tests, a more detailed investigation of need was undertaken.

The nature of the instructional problem and the need was related closely to the concept of fitness (and thus fitness testing) expressed in the Grade X programme manual. Now, while no statement of the concept of fitness is made in the student manual (Saunders, 1977), certain clues do exist. On page 37 the following statement can be found.

> We can generally establish as a satisfactory level of physical fitness the standard of 50 ml/(sic) of O_2 consumed per kilogram of body weight per minute.

This is a clear indication that the concept of fitness is based upon what is known as maximum oxygen uptake; that is, a measure of the body's ability to use oxygen to break down foods to produce usable energy.

This concept, and the tests based on it, have a long and honourable history of scientific acceptance as the single best indicator of a person's physical fitness level (Astrand and Saltin, 1961)

The score obtained by an individual on a test of maximum oxygen uptake is known as his/her Max. VO_2.

With this in mind the need can be expressed more finitely as follows:

i. A need for the student to understand the biological functions involved in the capture and utilization of oxygen.

ii. A need for the student to understand the limitations of the body to use the oxygen surrounding it.

iii. A need for the student to understand that the concept of fitness is; that cardio-vascular respiratory fitness is a function of the ability of the body to capture and utilize oxygen.

iv. A need for the student to understand that a test, called a maximum oxygen uptake test, can measure the ability of the body to capture and utilize oxygen

v. A need for the student to understand the rationale behind, and the methodology of, the maximum oxygen uptake test.

vi. A need for the student to be able to calculate a Max. VO_2 score when given the appropriate data.

vii. A need for the student to be able to interpret a Max. VO_2 score in terms of its indication of level of fitness.

To further substantiate need, 13 physical education teachers involved in teaching the Grade X programme were interviewed by the author. All thirteen of the teachers completed a questionnaire (see Appendix A) concerning the areas of the applied physiology programme which the teachers felt required additional instructional material.

Each teacher was requested to indicate (in rank order) the three areas which he or she considered most in need of additional material. The subject selected as being most in need by a teacher scored 3 points with 2 and 1 point(s) going to the second and third choice.

Table I shows the point scores for each of the nine subject areas as well as the final composite rankings.

From Table I it can be seen that the three highest ranked subject areas were:

1. Measurement of fitness
2. Maximum oxygen uptake test

3. The functioning of the heart.

TABLE I

POINT TOTALS AND FINAL RANKINGS FOR EXPRESSED NEED FOR VARIOUS SUBJECT AREAS

Area	Total points	Final rank
Function of the heart	16	3rd
Function of the lungs	9	4th
Function of muscles	1	7th
Function of blood	4	5th
Measurment of fitness	23	1st
Maximum oxygen uptake test	19	2nd
Measurement of strength	1	7th
Measurement of flexibility	0	9th
Long term effect of exercise	4	5th

The three top ranked areas were clearly considered more important than any of the remaining areas by the teachers involved in the survey. These teachers represented almost half (approx. 46%) of the teachers known to be involved in the Grade X programme[1].

[1] Based on the 28 schools listed by the Dept. of Education (Newfoundland) as offering the Grade X programme in October 1978. This may well be an under estimate of the true number.

The survey results clearly support the expressed opinion of the Provincial physical education consultant and established beyond reasonable doubt the need for additional instructional materials in the area of measurement of fitness and maximum oxygen uptake testing

Alternative Solutions

Three distinct alternative solutions to meeting the instructional need were considered. These were:

i. To bring the testing materials, personnel and expertise to the schools.

ii. To take the students to an institution in which the materials, personnel and expertise were available.

iii. To obtain or produce and instructional package, covering the appropriate materials, for use in schools.

The first alternative, performing the Max. VO_2 test in the schools, was rejected on two grounds. In the first instance the test itself is stressful for the subject to a degree which the schools would find unacceptable. Secondly the equipment required to perform the test is expensive (in the order of $10,000 to $15,000)

and requires highly trained operators.

The second alternative, taking the pupils to institutions where the test could be performed, was also rejected. At the present time only Memorial University of Newfoundland and a few of the larger hospitals in the Province have the required equipment. Even if arrangements could be made to use this equipment only a very small percentage of the total student population would have access to it. Thus this alternative was not considered viable.

The third alternative, and the preferred approach, was to obtain or produce a suitable instructional package.

Available Material

A thorough, ongoing, search by the author, the Provincial physical education consultant and the teachers involved in the Grade X programme failed to locate any materials suitable either with respect to content or grade level, most of the texts having been written for senior level university courses.

Thus the decision was made to produce an instructional package. From the results of the survey (Table I) it was decided to limit the scope of the instructional package to the areas of measurement of fitness and the maximum oxygen uptake test.

Rationale for Development

The rationale for development was based upon the sequential relationship between the componenent parts. All comprehension of the maximum oxygen uptake test is based, ultimately, on an understanding of the biological phenomena involved.

Thus a four part approach was selected.

Part I

a. A review of the individual biological functions.

b. An integration of the biological changes induced by exercise.

c. An explanation of the factors limiting the severity of work which a person can perform.

d. The relationship of the factors in (c) above to the maximum oxygen uptake test.

e. The theory of the maximum oxygen uptake test.

Part II

a. The presentation of the stages of a maximum oxygen uptake test.

b. The recording of data from tests

Part III

a. The calculation of a Max. VO_2 score from data supplied.

Part IV

a. The interpretation of test scores.

This rationale imposed several restraints, the most serious of which concerned the student's ability to progress through the material. The important consideration was that due to a variety of backgrounds and abilities the instructional package would have to allow each student to progress at his/her optimal rate.

CHAPTER II

LEARNER ANALYSIS

The education process is a complete interaction between all of its component elements. Perhaps the most important of the elements is the learner himself. The view has been expressed (Lindgren, 1967) that;

> The learner is important....not only because people are more important than processes or situations but primarily because without the learner there is no learning.

Thus, those characteristics of the learner which have a bearing on his ability to learn had to be considered by the developer of the instructional package.

General Characteristics

The instructional package was developed for use as an integral part of the Grade X credit physical education programme in the Province of Newfoundland and thus the target population was clearly and closely defined.

In general the pupils fell within the age range of 15-17 years, and by virtue of their Grade X promotion were considered to be literate to the extent of reading and writing general, non-technical, material. Also they were considered capable of mathematics, at least within the realm of simple arithmetic functions. This is not to say that many of the students did not have abilities and skills far beyond those listed. Those stated represent the minimum accomplishment for any member of target population.

Within the specific field of physical education the students had no common core of knowledge. Prior to Grade X they had undertaken a variety of Grade IX physical education programmes. For most of the students there had been no class-room, or academic, component of the programme. This precluded, for the most part, the acquisition of technical information concerning fitness testing.

At the Grade X level all students had worked from the Department of Education's publication, The Human Energy System, (Saunders, 1977) to a greater or lesser degree and thus can be considered tentitivly familiar with it. The

section, "Measuring Physical Fitness" (page 29) is basically descriptive and gives an overview of the types of test which can be performed. It contains neither an explanation of the rationale for the tests or detailed instructions concerning the performance of the tests. Thus for the purpose of the design of the instructional package it was considered that knowledge of maximum oxygen uptake testing was minimal or non-existent in the target population.

Specific Relevant Background

Even though no knowledge of the maximum oxygen uptake test was assumed, this did not mean that all of the target population entered the instructional material with the same (ie. zero) background knowledge.

The maximum oxygen uptake test is based on the relationship between the cardio-vascular and the respiratory systems of the body. Comprehension of the test is dependant on a working knowledge of these systems. Such knowledge might be acquired, by a proportion of the students, in high school biology classes. In view of this, strategies to bring all of the target population to an adequate level of biological knowledge were considered essential.

Student Attitudes

No hard data was available concerning the attitudes of the students towards physical education. Certain inferences can, however, be drawn. It should be noted that physical education, at this point in time, is an optional subject and that the students had opted to participate of their own free will.

It should also be noted that the number of schools undertaking the programme has increased rapidly and that many of the schools which started out with only a Grade X programme have now expanded to include Grade XI.

All of the above support the inference that attitudes towards the subject were probably positive.

Implications

The learner analysis indicated that the following points were of importance. All were considered during the production of the instructional package.

i. That normal descriptive language of a level suitable for Grade X students could be used.

ii. That all technical terms needed to be defined and explained as a knowledge of any such terms could not be assumed

iii. That all required biological background material needed to be included and that such material needed to be constructed in such a way that it would serve as review material for those with a biological background while at the same time serving as instructional material for the remainder.

iv. That the students had the arithmetic skills to deal with the calculation of the Max. VO_2 score provided that the method of calculation was presented.

v. That the students had an attitude positive towards the subject matter and that therefore the production of attitude change material was not required.

CHAPTER III

TASK ANALYSIS

A task analysis was undertaken using temporal sequential flowcharting. That is, the elements to be mastered were placed in the temporal sequence most likely to lead to the desired learning outcomes.

To this end the overall requirements of the package were divided into four sub-packages which could be sequentially ordered.

The four sub-packages were:

i. The biological concepts underlying the maximum oxygen uptake test.

ii. The apparatus and methodology of the maximum oxygen uptake test.

iii. The calculation of Max. VO_2 from test data.

iv. The interpretation of the test scores.

Figure 1 shows the relationship of the four sub-packages to the overall package, while figures 2 to 5 show the components within each of the sub-packages.

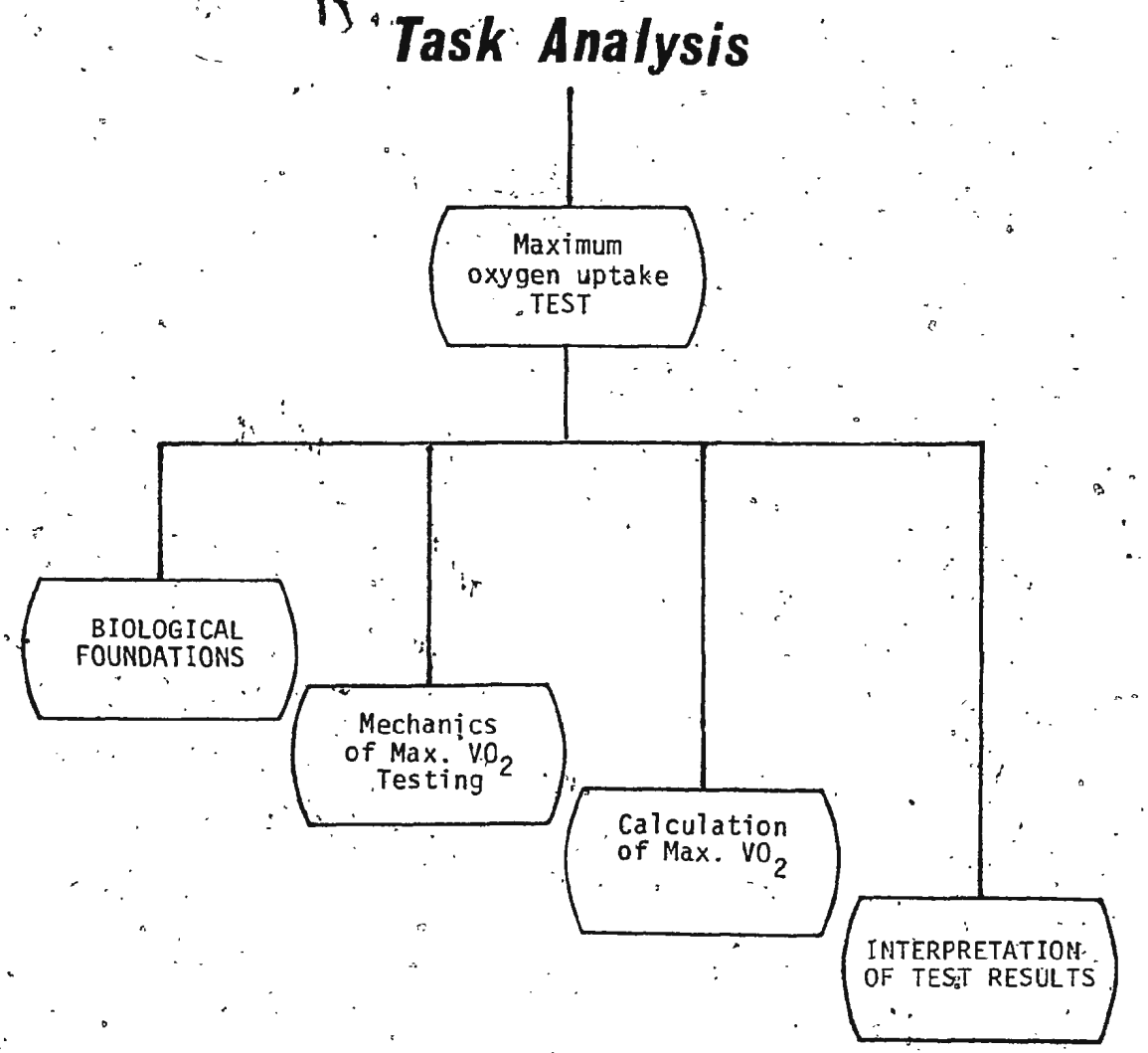

Task Analysis
Maximum oxygen uptake TEST
BIOLOGICAL FOUNDATIONS
Mechanics of Max. VO_2 Testing
Calculation of Max. VO_2
INTERPRETATION OF TEST RESULTS

Figure 1

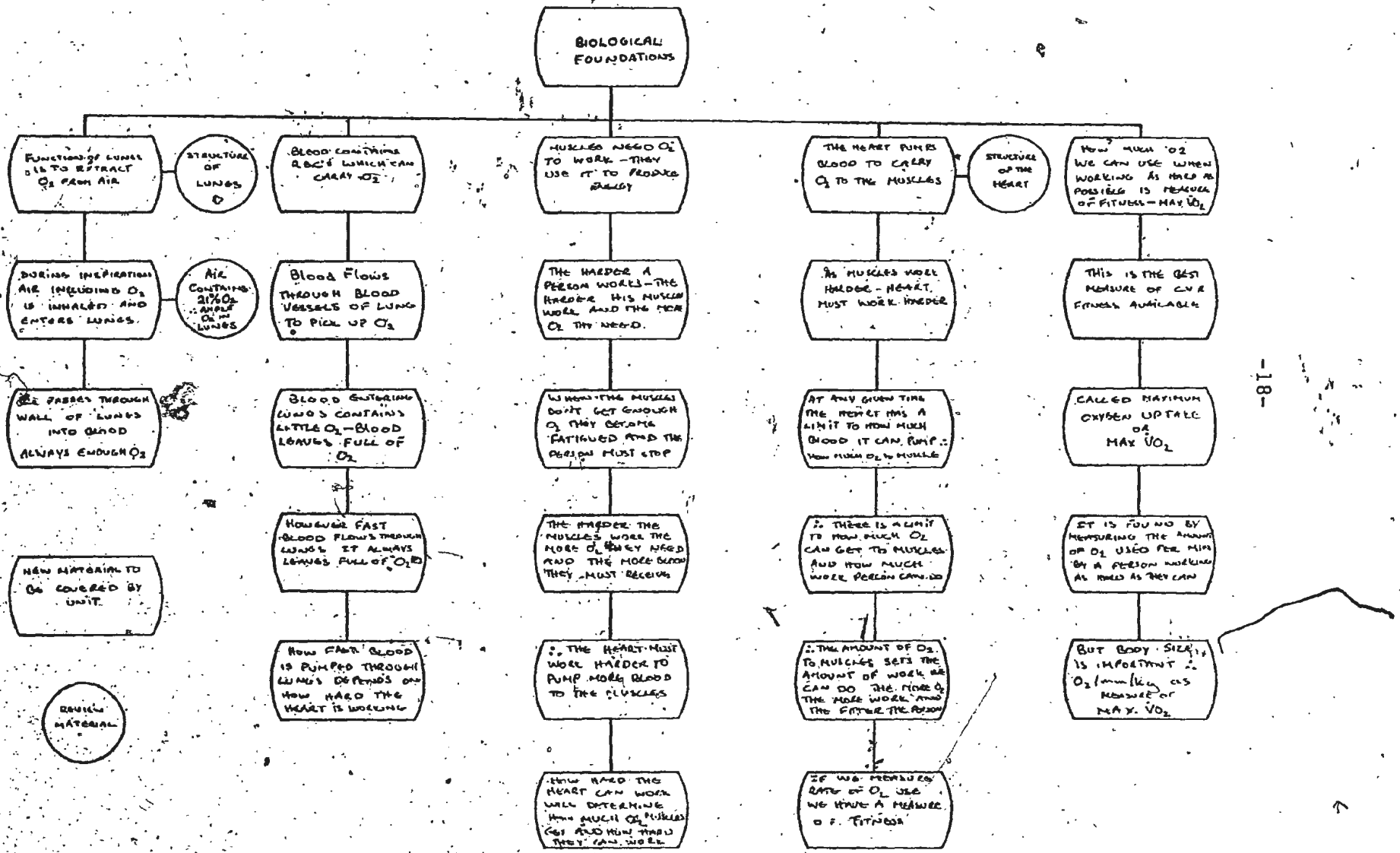

BIOLOGICAL FOUNDATIONS
FUNCTIONS OF LUNGS IS TO EXTRACT O_2 FROM AIR
STRUCTURE OF LUNGS
DURING INSPIRATION AIR INCLUDING O_2 IS INHALED AND ENTERS LUNGS.
AIR CONTAINS 21% O_2 ∴ ample O_2 in LUNGS
O_2 PASSES THROUGH WALL OF LUNGS INTO BLOOD ALWAYS ENOUGH O_2
NEW MATERIAL TO BE COVERED BY UNIT.
REVIEW MATERIAL
BLOOD CONTAINS RBC'S WHICH CAN CARRY O_2
BLOOD FLOWS THROUGH BLOOD VESSELS OF LUNGS TO PICK UP O_2
BLOOD ENTERING LUNGS CONTAINS LITTLE O_2 — BLOOD LEAVES FULL OF O_2
HOWEVER FAST BLOOD FLOWS THROUGH LUNGS IT ALWAYS LEAVES FULL OF O_2
HOW FAST BLOOD IS PUMPED THROUGH LUNGS DEPENDS ON HOW HARD THE HEART IS WORKING
MUSCLES NEED O_2 TO WORK — THEY USE IT TO PRODUCE ENERGY
THE HARDER A PERSON WORKS — THE HARDER HIS MUSCLES WORK AND THE MORE O_2 THEY NEED.
WHEN THE MUSCLES DON'T GET ENOUGH O_2 THEY BECOME FATIGUED AND THE PERSON MUST STOP
THE HARDER THE MUSCLES WORK THE MORE O_2 THEY NEED AND THE MORE BLOOD THEY MUST RECEIVE
∴ THE HEART MUST WORK HARDER TO PUMP MORE BLOOD TO THE MUSCLES
HOW HARD THE HEART CAN WORK WILL DETERMINE HOW MUCH O_2 MUSCLES GET AND HOW HARD THEY CAN WORK
THE HEART PUMPS BLOOD TO CARRY O_2 TO THE MUSCLES
STRUCTURE OF THE HEART
AS MUSCLES WORK HARDER — HEART MUST WORK HARDER
AT ANY GIVEN TIME THE HEART HAS A LIMIT TO HOW MUCH BLOOD IT CAN PUMP ∴ HOW MUCH O_2 TO MUSCLES
∴ THERE IS A LIMIT TO HOW MUCH O_2 CAN GET TO MUSCLES AND HOW MUCH WORK PERSON CAN DO
∴ THE AMOUNT OF O_2 TO MUSCLES SETS THE AMOUNT OF WORK WE CAN DO. THE MORE O_2 THE MORE WORK AND THE FITTER THE PERSON
IF WE MEASURE RATE OF O_2 USE WE HAVE A MEASURE OF FITNESS
HOW MUCH O_2 WE CAN USE WHEN WORKING AS HARD AS POSSIBLE IS MEASURE OF FITNESS — MAX $\dot{V}O_2$
THIS IS THE BEST MEASURE OF CVR FITNESS AVAILABLE
CALLED MAXIMUM OXYGEN UPTAKE OR MAX $\dot{V}O_2$
IT IS FOUND BY MEASURING THE AMOUNT OF O_2 USED PER MIN BY A PERSON WORKING AS HARD AS THEY CAN
BUT BODY SIZE IS IMPORTANT ∴ O_2/min/kg IS MEASURE OF MAX. $\dot{V}O_2$

Figure 2

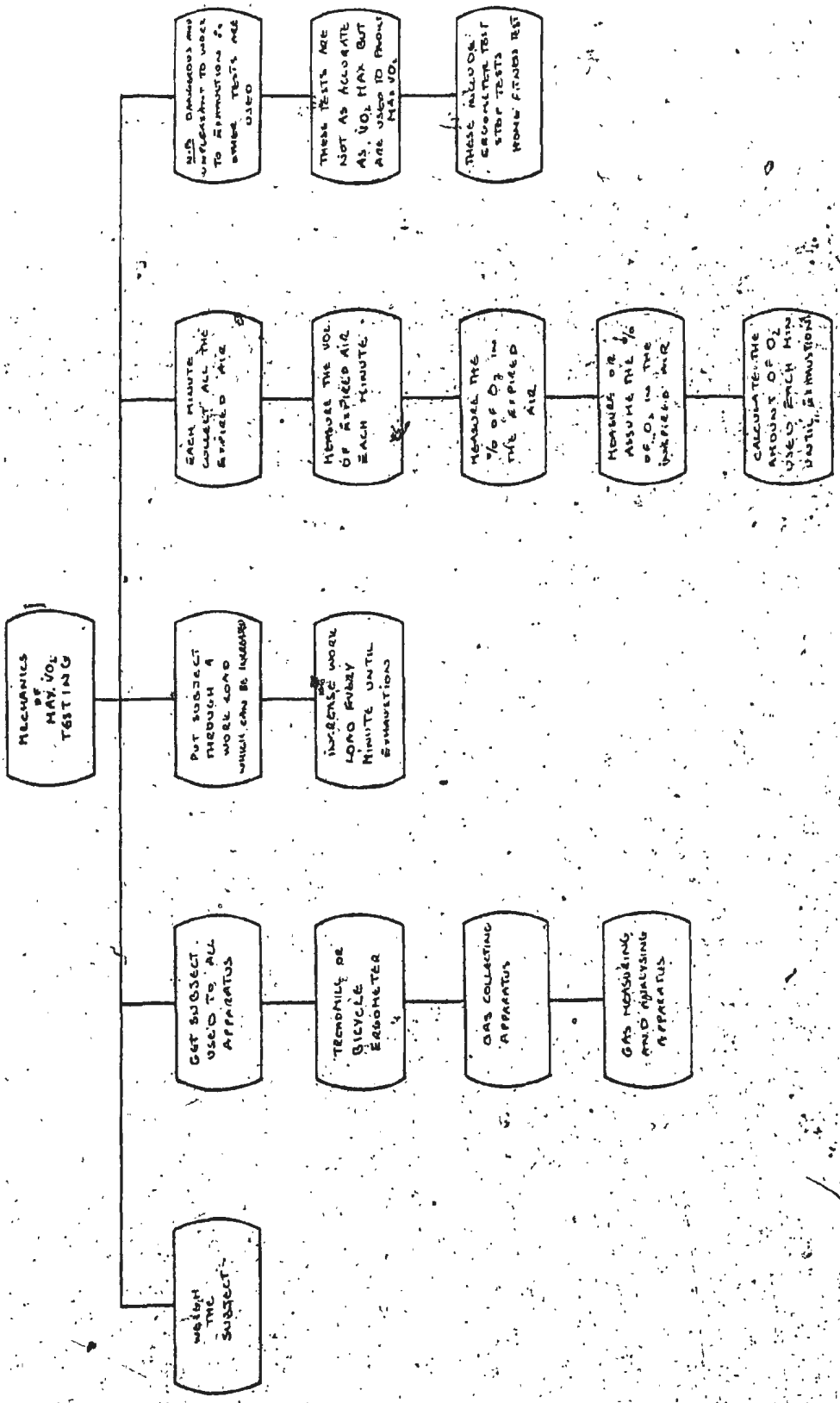

MECHANICS OF MAX. VO2 TESTING
WEIGH THE SUBJECT
GET SUBJECT USED TO ALL APPARATUS
TREADMILL OR BICYCLE ERGOMETER
GAS COLLECTING APPARATUS
GAS MEASURING AND ANALYZING APPARATUS
PUT SUBJECT THROUGH A WORK LOAD WHICH CAN BE INCREASED
INCREASE WORK LOAD EVERY MINUTE UNTIL EXHAUSTION
EACH MINUTE COLLECT ALL THE EXPIRED AIR
MEASURE THE VOL OF EXPIRED AIR EACH MINUTE
MEASURE THE % OF O2 IN THE EXPIRED AIR
MEASURE OR ASSUME THE % OF O2 IN THE INSPIRED AIR
CALCULATE THE AMOUNT OF O2 USED EACH MIN DURING EXERCISE
THESE TESTS ARE NOT AS ACCURATE AS VO2 MAX BUT ARE USED TO PROVIDE MAX VO2
THESE METHODS REQUIRE GREATER TEST STRESS THAN FITNESS TEST

Figure 3

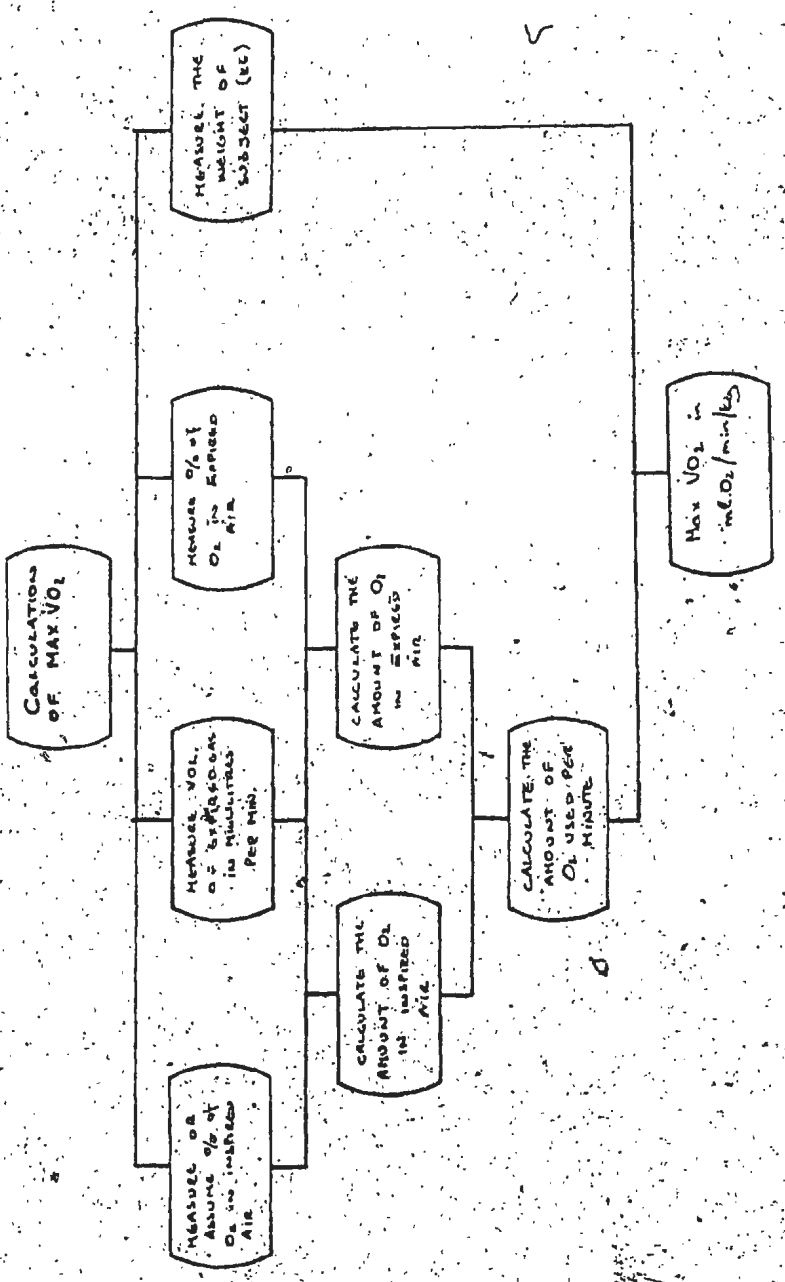

CALCULATION OF MAX VO_2
MEASURE THE WEIGHT OF SUBJECT (KG)
MEASURE % OF O_2 IN EXPIRED AIR
MEASURE VOL. OF EXPIRED AIR IN LITRES PER MIN.
MEASURE OR ASSUME % OF O_2 IN INSPIRED AIR
CALCULATE THE AMOUNT OF O_2 IN EXPIRED AIR
CALCULATE THE AMOUNT OF O_2 IN INSPIRED AIR
CALCULATE THE AMOUNT OF O_2 USED PER MINUTE
MAX VO_2 in ml.O_2/min/kg

Figure 4

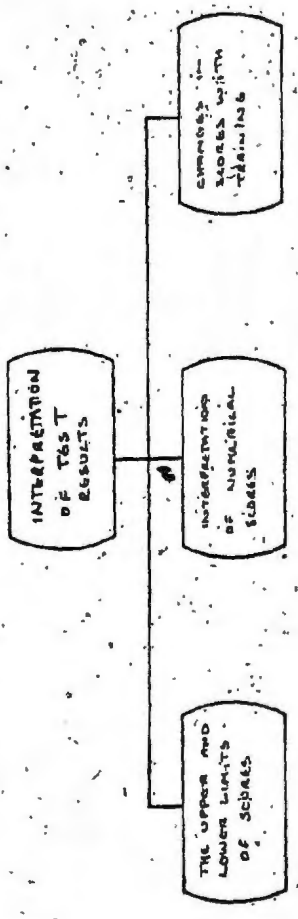

INTERPRETATION OF TEST RESULTS
INTERPRETATION OF NORMATIVE SCORES
THE UPPER AND LOWER LIMITS OF SCORES

Figure 5

Each of the figures (1-5) is a flow chart and can be read in the same way. Starting from the top of the chart the solid pathway is followed until branching occurs. At any branching point the earliest material in the sequence is that presented furthest to the left. The material in the block furthest left is completed prior to starting on the next block to the right. Where more than one item appears at the same horizontal level that to the left is the earliest.

Assumptions and Entry Behaviour

By virtue of the nature of the credit physical education programme it appeals to students of a variety of abilities and backgrounds. Some have an in-depth background in one or more of the sciences while others do not. Because of this no common assumptions regarding background were made.

Thus, the major assumption and the sole entry requirement was that the learner was capable of reading at a level appropriate for Grade X and that they be capable of performing simple arithmetic computations.

Behavioural Objectives

All behavioural objectives were constructed such that they were suitable for testing using pencil and paper tests. The five sub-sets of objectives represent one sub-set for each of the sub-packages with one sub-set for the overall instructional package.

The criterion for acceptable performance, for the instructional package, was that 80% of the sample of the target population would achieve 80% (or more) of the objectives.

Sub-set I

That given a diagram of the circulatory and respiratory systems, along with names of the anatomical parts, the student will be able to match parts and names correctly. The following anatomical parts to be tested.

a. The heart.
b. Veins.
c. Arteries.
d. Trachea.
f. Bronchioles.
g. Alveoli.

h. Capillary.

That in an objective test the student will correctly answer questions covering the following material.

j. The function of the lungs is to extract oxygen from the air.

k. That the oxygen passes through the walls of the lungs and into the capillary (blood).

l. That the blood entering the lungs contains very little oxygen.

m. That the blood leaving the lungs is full of oxygen.

n. That however fast the blood flows through the lungs it leaves full of oxygen.

o. That muscles need food and oxygen to produce energy.

p. That the harder a person works the more oxygen he uses.

q. That if the muscles do not get the oxygen they need they are forced to stop working.

r. That the heart pumps oxygen rich blood to the muscles.

s. That how much blood the heart is able to pump will determine how hard a person can work.

t. That there is a limit to how much oxygen rich blood the heart is able to pump per minute.

u. That the amount of oxygen rich blood which arrives at the muscles determines how much work a person can do.

v. That the maximum amount of oxygen a person can use per minute is a measure of how fit he is.

w. That the maximum amount of oxygen a person can use is called his maximum oxygen uptake.

x. That different size people need different amounts of oxygen to do the same amount of work.

y. That to get a Max. VO_2 score the amount of oxygen used in a minute is divided by the subject's weight.

z. That Max. VO_2 is measured in ml. O_2/kg/min.

Sub-set II

a. That given a list of all of the steps in the performance of a maximum oxygen uptake test the student will be able to place them in the correct order.

b. That the student will be able to identify the four essential measurements which must be made to obtain a Max. VO_2 score.

c, That the student will identify that Max. VO_2 measurements are made in the last minute of strenuous exercise.

Sub-set III

a. That given the amount of gas exhaled per minute, the percentage of oxygen in that gas, the oxygen content of inspired air and the weight of the subject, the student will be able to calculate a Max. VO_2 score. The formula for the calculation will be given.

Sub-set IV

a. That given a set of Max. VO_2 scores the student will be able to place them in categories of excellent, desirable, fair and poor fitness levels with 80% accuracy.

Sub-set V

a. That the student will be able to state that the maximum oxygen uptake test is the best available measure of physical fitness.

b. That the maximum oxygen uptake test is a measure of how well the body can extract oxygen from the air.

c. That the maximum oxygen uptake test is a measure of the hearts ability to pump blood.

d. That most other fitness tests are only estimates of maximum oxygen uptake.

e. That the maximum oxygen uptake test is a very strenuous test that should only be performed after the subject has had a medical examination.

f. That Max. VO_2 scores can be improved by training.[1]

[1]All objectives are referred to by their sub-section Roman numeral and by their letter sub-script. That is V_f.

CHAPTER IV

CHOICE OF MEDIA

The selection of a medium or media combination was dictated by three independant factors. These were:

i. The effectivness of alternate media.

ii. Production constraints.

iii. User constraints.

Media Effectivness

Thirteen physical education teachers, representing 46% of the teachers known to be involved in the Grade X credit programme were asked to rate each of 11 media/ media combinations with regard to their effectivness. Specifically they were asked to rate their effectivness in the teaching of applied physiology. A questionnaire utilizing a three point rating scale was used. The ratings were: 1-effective, 2-neutral and 3-ineffective. For questionnaire see Appendix B

For each of the media/media combinations a group mean rating was calculated. Table II shows the medial and their respective perceived effectivness.

TABLE II

THE PERCEIVED EFFECTIVNESS OF 11 MEDIA OR MEDIA COMBINATIONS

Media	Effective Neutral Ineffective	Score
Audio tapes		2.8
Slides		1.7
Filmstrip		1.8
Video-tape		1.2
Student Booklet		1.3
Slide+tape		1.3
Slide+script		1.6
Filmstrip+ tape		1.5
Filmstrip+ script		1.6
Booklet+ slide+script		1.2
Booklet+ script+ filmstrip		1.3
Group Mean rating	1 1.5 2 2.5 3	

From Table II it can be seen that media combinations which were considered to be most effective were:

i. Video-tapes

ii. Booklet + slides + script

iii. Slide + tape

iv. Booklet + filmstrip + script

v. Student booklet only.

It should be noted that i and ii were joint equal first choices while iii, iv and v all scored equally and were only slightly behind the leading two. On this basis any one of the five listed media/media combinations would have proved satisfactory with regard to effectivness.

Production Constraints

Because of technical and financial limitations, certain media were considered to be beyond the scope of the author. Both 16mm and Super 8mm movie film were discounted on these grounds. All remaining media (ie. those included in the survey) were considered feasible.

User Constraints

In addition to rating effectivness, the 13 teachers were asked to make a rating concerning the practicality of each medium/media combination in their own school situation. A three point rating of 1-practical, 2-neutral and 3-impractical was used. (For details see questionnaire Appendix B)

Table III shows the practicality ratings.

TABLE III

THE PERCEIVED PRACTICALITY OF 11 MEDIA/MEDIA COMBINATIONS

Media	Practical Neutral Impractical	Score
Audio-tapes		1.4
Slides		1.8
Filmstrip		1.1
Video-tapes		2.8
Student Booklet		1.0
Slide + tape		2.2
Slide + script		1.4
Filmstrip + tape		2.6
Filmstrip + script		1.2
Booklet + slide + script		1.5
Booklet + filmstrip + script.		1.3
Group Mean	1 1.5 2 2.5 3	

From Table III it can be seen that video-tapes, slide + tape and filmstrip + tape must be discounted due to the virtual consensus regarding the impracticality of these media in Newfoundland's schools.

The media considered most practical by the teachers were:

i. Student booklet

ii. Filmstrip

iii. Filmstrip + script.

Direct questioning of the respondants concerning their preference of media gave inconclusive results as the expressed differences between those listed above was slight.

Selection of Media

Resolution of the divergent viewpoints concerning choice of media was achieved using a three stage process.

Stage One - From the eleven listed media/media combinations those which were unsuitable on production grounds were eliminated.

Stage Two - Those media which were considered ineffective (audio-tapes) and/or impractical (video-

tapes) were eliminated.

Stage Three - A combined effectivness-practicality, EP-score, was calculated for each medium/media combination. In both the effectivness and the practicality ratings a low score was "better" and represented a more ideal medium.

Equal weighting was given to both effectivness and practicality and the EP-scores were calculated by finding the product of the mean effectivness rating and the mean practicality rating for each medium/media combination. In this also, a lower score represents a more ideal medium.

It should be noted that the EP-scores have a theoretical range of one to nine, with one representing an ideal medium/media combination and nine representing an impractical and ineffective medium/media combination.

TABLE IV

EP-SCORES FOR 11 MEDIA/MEDIA COMBINATIONS

Audio-tapes	3.92
Slides	3.06
Filmstrip	1.98
Video-tapes	3.36
Student Booklet	1.30*
Slide + tape	2.86
Slide + script	2.24
Filmstrip + tape	3.90
Filmstrip + script	1.92
Booklet + slide + script	1.80
Booklet + script + filmstrip	1.69

*The preferred medium.

From Table IV it can be seen that the student booklet has a score which most nearly approaches the ideal.

On the basis of this score a decision was made to produce the instructional package in the form of a self contained student booklet.

CHAPTER V

PRODUCTION AND FORMATIVE EVALUATION

The instructional booklet was produced within certain constraints imposed by the facilities and equipment available to the author and by the proposed method of later mass production.

It was decided that, at least until the completion of the summative evaluation, all reproduction would be by way of Xerox copies. Because of this all illustrations were limited to black and white line drawings.

All page masters containing illustrations were produced on 16" x 12" paper, with the hand produced line drawings being overlaid with text produced on an I.B.M. typewriter using ORATOR typeface. The page master was then photographically reduced to a standard 8½" x 11" paper size.

In all cases bold headings and key words were

produced using dry transfer letters.

Formative Evaluation

Formative evaluation was undertaken using a two stage approach. First, the material was studied by (a) a content expert who was asked to scrutinize the material with respect to the accuracy of the factual content. (b) learner experts who were asked to study the material with emphasis on the suitability of the material for the proposed target population. (c) a media expert who was asked to make comment on the clarity and effectivness of the use of the chosen media.[1]

Secondly the material was used by a group of twenty-five Grade X students enrolled in credit physical education classes at two schools.

In the case of the content, learner and media specialists an interview between the specialist and the author was arranged and at which all suggestions for improvement were recorded. All improvements suggested by the specialists were incorporated into a second draft used by the students.

In the case of the students the author administered the instructional package during a regularly scheduled class period. At the end of the period of study the students were asked to indicate, on a blank sheet provided, the best and worst aspects of the instructional package.

[1]For details of specialists see Appendix F

In addition, the students were asked to indicate which areas of the instructional package required further elaboration to aid comprehension. Information from the questions concerning the best and worst aspects was of little use as all of the comments were either highly favorable or were negative in a vague or general manner. Information from the section regarding areas which required amplification indicated that it was in the area of the calculation of Max. VO_2 that additional instructional material was needed.

After the inclusion of additional material covering the calculation of Max. VO_2 the instructional package was considered ready for a more formal, summative, evaluation.

CHAPTER VI

SUMMATIVE EVALUATION

Through the kind cooperation of both the Avalon North Integrated and the Avalon Consolidated school boards, testing was possible in two designated schools.

The students used for the testing of the instructional package were all regular members of the Grade X credit physical education classes at their respective schools.

Table V gives basic biographical data for the students (n=53).

TABLE V

SUBJECTS - BIOGRAPHICAL DATA

Sex	Number	Age	
		Mean	Standard Dev.
Male	32	15.7	0.38
Female	21	15.4	0.32
Total	53	15.6	0.36

Experimental Design

All students (n=53) were randomly assigned to one of two groups. Group A (n=26) was given a pre-test, the experimental treatment (ie. the instructional material and the time to work through it) and a post-test. Group B (n=27) were assigned a dummy pre-test, the treatment (as for group A) and the post-test. This design was used in an attempt to measure the effect of the pre-test on post-test performance.

Testing Instrument

Both groups wrote identical post-tests while group A additionally wrote the same test instrument as a pre-test.

The test instrument consisted of 31 objective questions, in the majority of which the student was required to write in a single word (or short phrase) answer. This design was used to minimize the possibility of the student making a guess at the answer.

Table VI lists the objectives which it was hoped the instructional package would meet along with the question(s) which test that objective. The notation for the objectives is consistant with that in Chapter Three.

TABLE VI

OBJECTIVES AND THE QUESTIONS TESTING THEM

Objective	Question	Objective	Question
I a	24	II a	12
b	25	b	13
c	26	c	14
d	27		
e	28	III a	15
f	29		
g	30		
h	31	IV a	16
j	1		
k	2	V a	17
l		b	20
m	3	c	19
n		d	22
o	4	e	21
p	18	f	23
q	5		
r	6		
s	7		
t	19		
u	7		
v	8		
w	9		
x	10		
y	10		
z	11		

Testing Procedure

All subjects were given an identification code number to be placed on their booklet, pre-test and post-test. The subjects were then randomly assigned to either group A or group B by virtue of their receiving or not receiving the pre-test. Those who did not receive the

pre-test were administered a dummy pre-test of comparable difficulty designed to take the same time to complete. The dummy pre-tests were concerned with anatomical identification and were discretely discarded following the completion of the testing procedure.

All subjects were then given one hour in which to study the material and work through the associated problems. During this period the author turned down all requests for additional information and asked the student to see him later if the information was still required. In this manner the instructional material was in no case supplemented by verbal input.

Following exposure to the instructional material all students wrote the post-test.

Included with the post-test was a very short questionnaire designed to collect basic biographical data, ie.

i. The student's age and sex

ii. The student's exposure to high school biology.

iii. The student's attitude towards the instructional package.

iv. The student's attitude towards physical education.

Analysis of Data

The data was analysed in an attempt to answer the following questions:

i. To what extent did learning occur?

ii. Did the instructional package meet its stated objectives?

iii. What was the effect of the pre-test on post-test performance?

iv. What was the effect of exposure to high school biology on pre-test and post-test performance?

Extent of Learning Accomplishment

The degree to which learning occured was measured in three ways.

i. By the comparison of pre-test and post-test scores.

ii. By a pre-test post-test item analysis.

iii. By the calculation of success, failure, pre-knowledge and interference indices.

Table VII shows the pre-test and post-test raw scores and percentages for group A, (n=26). It should be noted that raw scores are reported as the number of scores correct out of the possible maximum of 31.

TABLE VII

RAW SCORES AND PERCENTAGES ON PRE-TEST AND POST-TEST (GROUP A)

Subject number	Pre-test scores Raw score	%	Post-test scores Raw score	%
1	7	22.58	31	100.00
2	3	9.68	30	96.77
3	9	29.03	28	90.32
4	11	35.48	29	93.55
5	7	22.58	27	87.10
6	5	16.13	26	83.87
7	3	9.68	24	77.42
8	1	3.23	28	90.32
9	2	6.45	26	83.87
10	3	9.68	31	100.00
11	3	9.68	21	67.74
12	0	0.00	28	90.32
13	3	9.68	21	67.74
14	3	9.68	29	93.55
15	3	9.68	31	100.00
16	1	3.23	28	90.32
17	2	6.45	27	87.10
18	3	9.68	25	80.65
19	6	19.35	24	77.42
20	5	16.13	31	100.00
21	5	16.13	29	93.55
22	1	3.32	30	96.77
23	3	9.68	28	90.32
24	6	19.35	30	96.77
25	0	0.00	16	51.61
26	4	12.90	28	90.32
Mean	3.80	27.15	27.15	87.59

From Table VII it can be seen that the average pre-test score was 3.80 (27.15%) with an average post-test score of 27.15 (87.59%). A t-test for dependant samples was performed on the pre-test/post-test data. It indicated that the difference between the means was significant at well beyond the 0.005 level. A t-score of 31.30 was obtained with 4.31 required at α=0.005.

Thus it can be concluded that learning, as measured by scores on the test instrument, occurred to a highly significant degree.

Item Analysis

An item analysis was carried out to determine the extent to which learning occured on each specific objective. Table VIII shows the number (and percentage) of correct responses, for pre-test and post-test, for each of the test items. The difference between the numbers scoring correctly on the post-test and pre-test was tested for significance using χ^2 analysis.

TABLE VIII

PRE-TEST/POST-TEST ITEM ANALYSIS

Question number	Pre-test #	Pre-test %	Post-test #	Post-test %	χ^2	
1	9	34.00	25	96.15	28.44	***
2	0	0.00	22	84.62	∞	***
3	0	0.00	23	88.46	∞	***
4	3	11.54	24	92.31	147.00	***
5	1	3.85	25	96.15	529.00	***
6						
6	17	65.38	26	100.00	4.76	*
7	1	3.85	23	88.46	484.00	***
8	1	3.85	22	84.62	441.00	***
9	0	0.00	24	92.31	∞	***
10	3	11.54	25	96.15	161.33	***
11	1	3.85	24	92.31	52.90	***
12	0	0.00	23	88.46	∞	***
13	0	0.00	21	80.77	∞	***
14	1	3.85	19	73.08	400.00	***
15	0	0.00	20	76.92	∞	***
16	2	7.69	21	80.77	200.00	***
17	4	15.38	26	100.00	121.00	***
18	1	3.85	26	100.00	484.00	***
19	2	7.69	26	100.00	242.00	***
20	2	7.69	24	92.31	200.00	***
21	0	0.00	26	100.00	∞	***
22	2	7.69	25	96.15	264.50	***
23	2	7.69	23	88.46	180.50	***
24	22	84.62	26	100.00	0.72	
25	10	38.46	23	88.46	16.90	***
26	10	38.46	23	88.46	16.90	***
27	2	7.69	22	84.62	200.00	***
28	1	3.85	22	84.62	441.00	***
29	3	11.54	22	84.62	120.33	***
30	3	11.54	22	84.62	120.33	***
31	3	11.54	22	84.62	120.33	***

* $p<.05$ ** $p<.01$ ***$p<.001$

From the item analysis it can be seen that all but two of the items showed pre-test/post-test increases which were significant at well beyond the $\alpha=0.001$ level. The exceptions to this were items 6 and 24. Item 6 was significant at the $\alpha=0.05$ level while item 24 showed no significant change. The low, and non-significance , respectivly appear to be due to the very high level of pre-test performance. In item 6, 65.38% scored correctly on the pre-test with 100% scoring correctly on the post-test. For item 24 the percentages were 84.62% on the pre-test and 100% on the post-test.

Thus it can be seen that highly significant improvements in performance were recorded on all but two of the test items. On both of the non-significant improvement items the post-test score was 100% and thus the lack of significance was probably due to a ceiling effect. Combined, these figures indicate that learning occured on all items.

Success, Failure, Pre-knowledge and Interference Indices.

For any item on which a pre-test, post-test design is used a given subject must fall into one of four catagories.

That is:

i. Item incorrect on the pre-test and correct on the post-test. (I1-C2)

ii. Item correct on both the pre-test and the post-test. (C1-C2)

iii. Item incorrect on both the pre-test and the post-test. (I1-I2)

iv. Item correct on the pre-test and incorrect on the post-test. (C1-I2)

Now, those subjects falling into group ii have not benefited from the instructional package by virtue of their previous knowledge, while those in group iii have failed to benefit by virtue of their continued ignorance of the material after completing the package. Group i represents those who have benefited from the package while those in group iv have had previously held correct information interfered with to the extent that they gave an incorrect answer on the post-test to a question on which they had previously scored. Where an element of chance is active in the selection of an answer this group may represent those who failed to learn the material but were successful in their guess on the pre-test but later guessed unsuccessfully.

Thus, from the numbers of subjects falling into the four groups it is possible to calculate:

a. The percentage of those who did not know the material on the pre-test who were able to score correctly on the post-test. This was defined as the success index.

b. The percentage of those who did not know the material on the pre-test and who failed to learn the material by virtue of exposure to the instructional package. This was defined as the failure index.

c. The pre-knowledge index refers to the percentage of the population which scored correctly on both the pre-test and the post-test. This group were assumed to have had previous knowledge of the material covered by the test item.

d. The interference index refers to the percentage of the population which, having scored correctly on an item on the pre-test, fails to score correctly on the post-test. It should be noted that due to the low number of subjects scoring correctly on the pre-tests a single subject then failing to

score on the post-test causes a high interference index to be obtained.

Table IX shows the four indices for each of the 31 test items.

From Table IX it can be seen that on average 89.08% of those who did not know an item on the pre-test were able to score correctly on the post-test, while 10.92% failed to do so.

Table IX also shows that on average 13.16% of the population had previous knowledge of the material covered and retained that knowledge through the post-test. It should be noted however that in actuality a very large proportion of the population scored correctly on both pre-test and post-test on only four of the test items. From the data it can also be seen that on average interference occured in 1.12% of the population, a figure which would appear to represent a chance fluctuation in scoring.

TABLE IX

SUCCESS, FAILURE, PRE-KNOWLEDGE AND INTERFERENCE INDICES FOR EACH ITEM

Question number	Number of people per group I1-C2	C1-C2	I1-I2	C1-I2	Success Index	Failure Index	Pre-knowledge Index	Interference Index
1	17	8	1	1	94.44	5.56	30.77	12.50
2	22	0	4	0	84.62	15.38	0.00	0.00
3	23	0	3	0	88.46	11.54	0.00	0.00
4	21	3	2	0	91.30	9.52	11.54	0.00
5	23	1	2	0	92.00	8.00	3.35	0.00
6	9	17	0	0	100.00	0.00	65.38	0.00
7	22	1	3	0	88.00	12.00	3.85	0.00
8	21	1	4	0	84.00	16.00	3.85	0.00
9	24	0	2	0	92.31	7.69	0.00	0.00
10	22	3	1	0	91.67	4.17	11.54	0.00
11	23	1	2	0	92.00	8.00	3.85	0.00
12	23	0	3	0	88.46	11.54	0.00	0.00
13	21	0	5	0	80.77	19.23	0.00	0.00
14	18	1	7	0	72.00	28.00	3.85	0.00
15	20	0	6	0	76.92	23.08	0.00	0.00
16	19	2	5	0	79.17	20.83	7.69	0.00
17	22	4	0	0	100.00	0.00	15.38	0.00
18	25	1	0	0	100.00	0.00	3.85	0.00
19	24	2	0	0	100.00	0.00	7.69	0.00
20	22	2	2	0	91.67	8.33	7.69	0.00

TABLE IX

Question number	Number of people per group I1-C2	C1-C2	I1-I2	C1-I2	Success Index	Failure Index	Pre-knowledge Index	Interference Index
21	26	0	0	0	100.00	0.00	0.00	0.00
22	23	2	2	0	92.00	8.00	7.69	0.00
23	22	2	2	0	91.67	8.33	7.69	0.00
24	4	22	0	0	100.00	0.00	86.62	0.00
25	14	9	2	1	87.50	12.50	38.46	11.11
26	14	9	2	1	87.50	12.50	38.46	11.11
27	20	2	4	0	83.33	16.67	7.69	0.00
28	21	1	4	0	84.00	16.00	3.85	0.00
29	19	3	4	0	82.61	17.39	11.59	0.00
30	19	3	4	0	82.61	17.39	11.59	0.00
31	19	3	4	0	82.61	17.39	11.59	0.00
				Average	89.08	10.92	13.16	1.12

Did the package meet its objectives?

From the combined scores of groups A and B, Table X, it can be seen that in excess of 84% of the sample achieved greater than 80% of the objectives. This surpasses the pre-defined criterion of acceptable[1] performance and thus the package can be said to have met its objectives.

TABLE X

THE PERCENTAGE OF STUDENTS WITH PERCENTAGE OF CORRECT ANSWERS

15.38%	scored	100%
26.92%	scored	95% or more
57.69%	scored	90% or more
65.38%	scored	85% or more
84.61%	scored	80% or more
15.39%	scored less than	80%

[1]Criterion for accectable performance was 80% of the students achieving 80% of the objectives.

Effect of Pre-test on Post-test performance

An F-test was performed in order to investigate possible differences between the means of the two group's post-test scores. With the mean for Group A (exposed to pre-test) 27.15, and the mean for Group B (not exposed to pre-test) equal to 27.86 no significant difference was established. The F-test score was 0.94. With df of 1,51 an F-score greater than 4.03 was required for significance at α=0.05.

From this it can be seen that exposure to the pre-test has no significant effect on post-test performance.

Effect of previous (or concurrent) biology

A biserial correlation between exposure to high school biology (either previous or concurrent) and test scores was calculated for both the pre-test and the post-test.

A high correlation on the pre-test was not matched by the post-test. From this the conclusion can be drawn that exposure to high school biology was perhaps instrumental in the attainment of high pre-test scores

but that it had no effect on, or relationship to, final achievment scores.

TABLE XI

BISERIAL CORRELATION BETWEEN EXPOSURE TO HIGH SCHOOL BIOLOGY AND TEST SCORES

Pre-test r_{bis}	= 0.94[1]
Post-test r_{bis}	= 0.08

Attitude towards the instructional package

On completion of the post-test all subjects were asked to rate both the instructional package and their physical education programme in general. The ratings were made on a five point scale with 'like a great deal' scoring 4 points and 'dislike a great deal' scoring zero. 'Like a little' and 'dislike a little' scored 3 and 1 respectivly with 'no feeling' neutral at a score of 2.

The mean score for the package was 3.46 compared to 3.61 for physical education in general. Using a

[1]It should be noted that for relativly small groups and certain variations of normal distribution r_{bis} can exceed 1.00. Thus r_{bis} is not directly comparable to other correlation scores.

t-test for dependant samples a t-score of 0.83 was obtained. With df=52 a t-score of 2.83 was required at $\alpha=0.05$. Thus it can be said that the attitude towards the instructional package was highly positive but not significantly different from the student's attitude towards physical education in general.

Discussion

From the data presented and the statistical tests performed it can be seen that overall the package was successful in meeting its objectives and in teaching to a significant degree.

The administration of the pre-test had no significant effect on post-test performance, and thus, in wider usage can be included or excluded at the teacher's discretion.

Biological background at the high school level was shown to be significantly related to pre-test scores but unrelated to post-test scores. Thus the package would appear to negate the effect of differing biological backgrounds.

Attitude towards the package was shown to be positive and closely related to the students attitude towards physical education in general.

Weaknesses

Both the raw data and the success/failure indices indicate that objective II_c (tested by question 14) fell short of the accepted 80%-80% criteria for acceptable performance.

Thus a decision was made that information in this area be strengthened. This was achieved by the addition (noted ΔΔ in the final ammended draft of the instructional package - see Appendix E) of a specific statement and reminder on the summary page to the effect that the expired air is collected during the last minute of strenuous exercise.

It should be noted that this modification to the instructional package was not tested. It was felt, by the author, that the marginal nature of the weakness and the simplicity of the added material made re-testing of the whole package superfluous.

CHAPTER VII

PROPOSED IMPLEMENTATION

Dissemination of the instructional package to Newfoundland schools will be undertaken in two separate ways. In the first instance the material will be available through the Resource Clearinghouse of the Division of Learning Resources, Memorial University of Newfoundland. In this situation the Clearinghouse will hold master copies of the booklet which individual schools will be permitted to duplicate at their own cost. This is seen as an interim, stop-gap, solution to the distribution problem.

Final, large scale, distribution is contingent upon the acceptance of the booklet, as a required text supplement, by the Provincial Physical Education Curriculum Committee. It is proposed that the instrct-ional package be submitted to the committee no later than its Spring session 1979. Before submission it is hoped to have the booklet master pages re-made with type set written material replacing the current typewritten

sections. This would allow the same information to be presented in a clearer, neater manner. No additional changes to the material are anticipated.

BIBLIOGRAPHY

Anderson, R.H. Selecting and developing media for instruction. Madison, Wisconsin: American Society for Training and Development, 1976.

Astrand, P.O., & Rodahl, K. Textbook of work physiology physiological bases of exercise. New York: McGraw-Hill Book Co., 1977.

Astrand, P.O., & Saltin, B. Maximal oxygen uptake and heart rate in various types of muscular activity. Journal of Applied Physiology, 1961, 16, 977-981.

Bjerstedt, A. Educational technology:instructional programming and didakometry. New York: Wiley-Interscience, 1972.

Government of Newfoundland and Labrador. The Education Act, 1968 (revised 1970)

Gropper, G.L. Instructional strategies. Englewood Cliffs: Educational Technology Publications, 1974.

Heidt, E.V. Instructional media and the individual learner. New York: Nichols Publishing Co., 1978.

Klasek, K.B. Instructional media in the modern school. Lincoln, Nebraska: Professional Educators Publications, 1972.

Lindgren, H.C. Readings in educational psychology (3rd. Ed.) New York: Wiley Publishing Co., 1967.

Saettler, P. A history of educational technology. New York: McGraw-Hill Book Co., 1968.

Thiagarajan, S., Semmel, D.S., & Semmel, M.I. Instructional development for training teachers of exceptional children: a sourcebook. Minneapolis, Min.: Council for Exceptional Children, 1974.

Winman, R.V. Instructional materials. Worthington, Ohio: C.A. Jones Publishing Co., 1972.

APPENDIX A

QUESTIONNAIRE

Within the APPLIED PHYSIOLOGY area of the Grade X Credit physical education programme there are many areas which required additional instructional materials. Please select the three areas, from those listed below, which YOU feel are MOST in need of additional instructional material.

When you have decided on the three which you feel need attention please rank the 1st 2nd & 3rd in need.

Area	Rank (three only)
Function of the heart.	
Function of the lungs	
Function of muscles	
Function of blood	
Measurment of fitness.	
Maximum oxygen uptake Testing.	
Measurment of strength.	
Measurment of flexibility.	
Long Term effects of exercise.	

APPENDIX B

QUESTIONNAIRE

Now obviously an instructional package can be produced in a variety of ways. Some of the media which can be used are such things as slides, filmstrips, audio tapes or student booklets. Not all of the media are as effective as each other and certainly they are not all equally practical for class room use. To ensure that the instructional package is produced in such a way that it will be of the greatest use to the greatest number of people I would seek you help in deciding the media in which it will be produced.

Listed below are several of the media which it is practical for me to produce. For each medium I would like to you to give TWO ratings. The first rating concerns how effective you think that particular medium is. For instance you might think that student booklets are a very effective way of presenting information while video-tapes are ineffective. Thus on the scales below you would indicate very effective with a 1 and ineffective with a 3.

The second rating concerns how practical you think the medium would be for YOU in YOUR SCHOOL. Thus if you have no video-tape player you would rate video-tapes as impracticable (3)

Media	Effective — Ineffective			Practical—Impracticable		
Audio tapes	1	2	3	1	2	3
Slides	1	2	3	1	2	3
Filmstrips	1	2	3	1	2	3
Video-tapes	1	2	3	1	2	3
Booklet only	1	2	3	1	2	3
Slide + tape	1	2	3	1	2	3
Slide + script	1	2	3	1	2	3
Filmstrip + Tape	1	2	3	1	2	3
Filmstrip + Script	1	2	3	1	2	3
Booklet + slide + script	1	2	3	1	2	3
Booklet + filmstrip + script	1	2	3	1	2	3

Having given thought to the various media and their ratings please think of the three most desirable forms of instructional package and rank them first, second and third.

1. Most desirable form of package 1

2. Next..... _____

3. Next..... _____

Thank You.

Appendix C

Questionnaire to obtain bibliographic data

The following questionnaire was used.

a. What is your age in years and months? ___yrs ___mo.

b. Sex? male Female (please circle one)

c. Are you how taking, or have you ever taken, a high school biology course? Yes No (please circle one)

d. Which of the following expresses how you felt about working through the booklet today?

liked a great deal
liked a little
no feeling
disliked a little
disliked a great deal Please tick one

e. Which of the following expresses how you feel about physical education classes in general?

like a great deal
like a little
no feeling
dislike a little
dislike a great deal Please tick one

Appendix D

The Test Instrument

The following test instrument was used as both the pre-test and the post-test. Each question is listed with the objectives tested by it.

Test Items

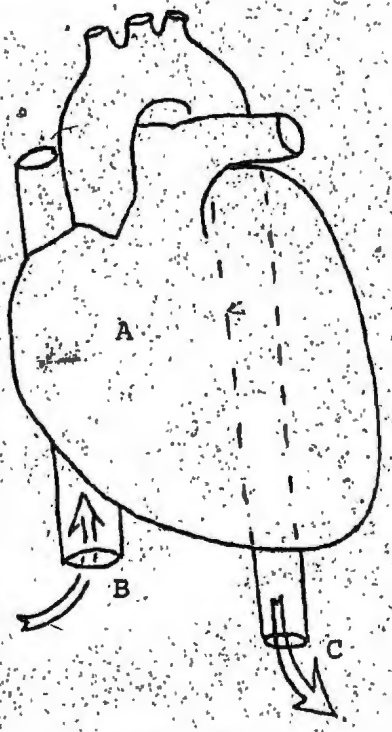
Objective Tested.	Question Number	
I-j	1.	The major function of the lungs is to extract oxygen from the _____.
I-k	2	The oxygen is able to pass through the wall of the alveoli into the _____.
I-l.m.n.	3	However fast blood flows through the lungs it always arrives containing _____ oxygen and leaves containing _____ oxygen.
I-o	4	To produce energy muscles need _____ and _____.
I-q	5	Usually when a muscle stops working it is because it does not have enough _____.
I-r	6	The _____ pumps oxygen rich blood to the muscles.
I-s.u.	7	How much work a person can do depends on how much _____ _____ blood arrives at the muscles.
I-y	8	How much oxygen can be used by the body and how much oxygen rich blood the _____ can pump, is a measure of _____.
I-w	9	The maximum amount of oxygen that a person can use in one minute is called his /her _____.
I-x.y.	10.	To get a Max. VO_2 score, the amount of oxygen used per minute is divided by the person's _____.
I-z	11	Which of the following is a Max. VO_2 score? a. 23 ml. O_2/kg/min b. 199 litres/kg/min c. 29 lbs.O_2/hr/m d. 106 cu.in/ml.

Objective Tested	Question number	
II-a	12	The following is a list of steps required to obtain a Max. VO2 score. Read the list and then place the steps in the correct order. Put a 1 beside the first step, 2 beside the second step, etc. ___ Calculate how much oxygen the subject used in one minute. ___ Calculate how much oxygen the subject breathed in, in one minute. ___ Work the subject to exhaustion, collect the expired air for one minute. ___ Collect all of the equipment together. ___ Measure how much air was expired in one minute. ___ Weigh the subject. Divide the amount of oxygen used in one minute by the weight of the subject. ___ Calculate the amount of oxygen the subject breathed out in one minute. ___ Take a sample of the expired air and measure how much O_2 it contained.
II-b	13	Below is a list of eight measurements only FOUR of which are required to calculate a Max. VO_2 score. Place a cross through the letter in front of the four which are required. a. Height b. Weight c. Sex d. Age

Objective Tested	Question number	
	13 (cont.)	e. Percentage of oxygen in air f. Percentage of oxygen in expired air. g. Volume of air expired. h. Volume of oxygen in blood.
II-c	14	Measurement of Max. VO_2 should be made a. Immediately after the person stops exercising. b. One minute after the person stops exercising c. One minute before the person stops exercising.
III-a	15	Calculate the Max. VO_2 score for the following person. He exhales 100,000 ml of oxygen in one minute. The INHALED air contained 21% oxygen and the EXHALED gas contained 15% oxygen. The person weighs 100 Kg. N.B The formula is given. Max. VO_2 = _____ ml. O_2/kg/min.
IV-a	16	On a Max. VO_2 test people get these scores: Bob-82, Bill-91, Chris-55 Ron-29, Eric-36 and John-63. Describe them as exceptionally fit, very fit desirable fit, fair fitness or low fitness. Bill is _____ Bob is _____ Chris is _____ Ron is _____ Eric is _____ John is _____

Objective Tested	Question number	
V-a	17	The Max. VO_2 test is the most _____ test of physical fitness.
I-p	18	The harder a person works the _____ oxygen he uses.
I-t V-c	19	Up to a limit, the harder a person works the more _____ _____ blood the heart pumps per minute.
V-b	20	The Max. VO_2 test is a measure of how well the body can extract _____ from the _____.
V-e	21	The Max. VO_2 test is very _____ and should only be performed after the subject has had a _____ examination.
V-d	22	Other fitness tests give an _____ of maximum oxygen uptake.
V-f	23	A person who takes a Max. VO_2 test and then trains hard for three months would expect a _____ score at the end of the training period.
I a-h	24-31	See diagrams on following page.

Match the letter with its correct name.



Capillary ____

Artery ____

Trachea ____

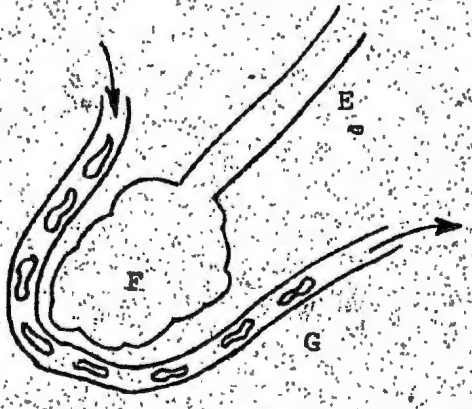
Alveoli ____

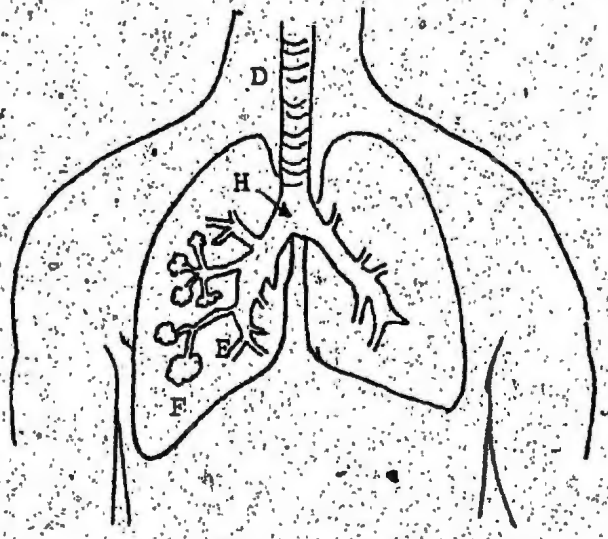
Bronchiole ____

Vein ____

Heart ____

Bronchus ____



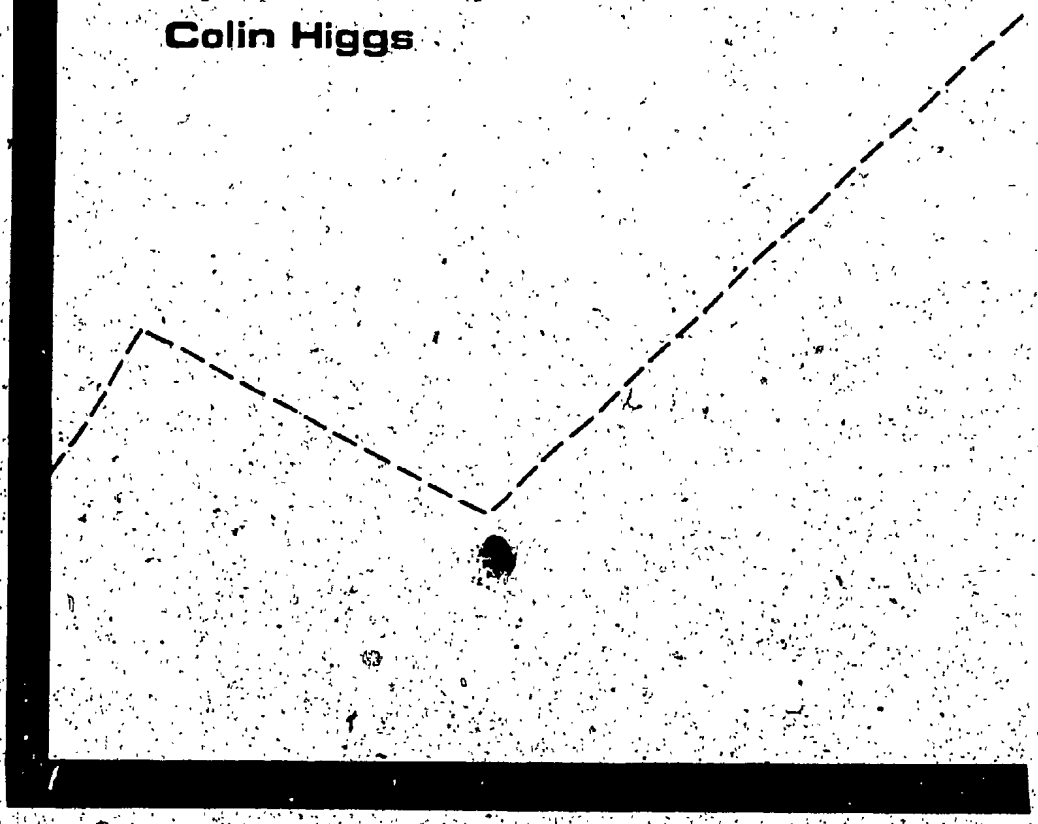


APPENDIX E

It should be noted that the teacher's manual contains the student's manual in its complete and final form. Thus only the teachers manual is included here.

Measuring Fitness

by
Colin Higgs



Teacher's Manual

Using the booklet

The student booklet, "Measuring Fitness", was designed written and field tested as a self-instructional manual. An integral part of the self-instruction is the set of questions which appear throughout the booklet. Students should be encouraged to WRITE IN THEIR ANSWERS TO THESE QUESTIONS as this reinforces the learning process.

While all of the material within the student manual can be covered by the student at one sitting of approx. 80 minutes it need not be. If the theory portion of the credit programme is covered during 40 minute periods it is suggested that the booklet be used for three periods.

i. The biological background.
ii. The test procedures
iii. Interpretation of test scores/alternate tests.

The role of the teacher

The booklet was field tested in situations in which the teacher played no role in the learning process. Thus the teacher is free to aid those students who are having difficulty with the material. In field testing of the booklet approximately 90% of the students attained 90% of the stated objectives. The objectives are listed in Appendix A.

Follow-up activities

Some follow-up activities are listed in Appendix B

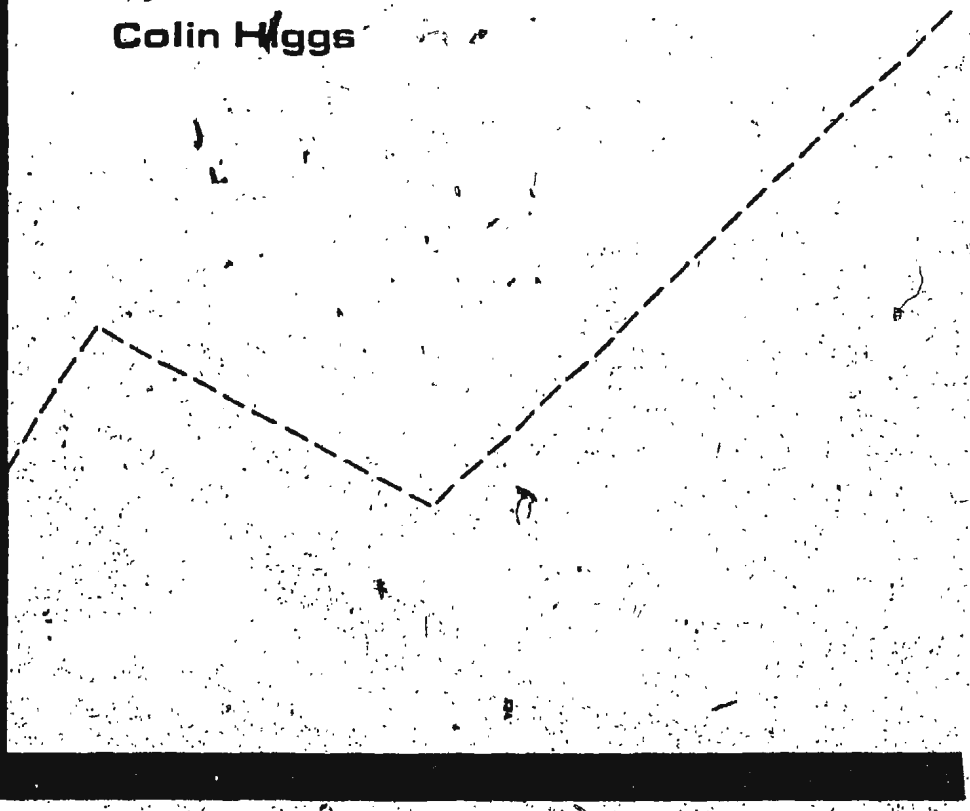
Additional references

Any teacher working in this field is encouraged to read (or re-read) Astrand's, "Textbook of Work Physiology", which is probably the best single reference text. Others are listed in Appendix C

Measuring Fitness

by

Colin Higgs



Student's Manual

Measuring Fitness
©1978

by

Colin Higgs

School of Physical Education & Athletics, Memorial University of Newfoundland.

In conjunction with,

Division of Learning Resources, Faculty of Education, Memorial University of Newfoundland.

Contents

Introduction

HOW DO YOU MEASURE FITNESS ?

In the past, many different fitness tests have been tried. Some of the tests were quite good, but many gave very inconsistant results.

Recently one test has been developed which is excellent. It is called a

MAXIMUM OXYGEN UPTAKE TEST

What makes it a good test is that the people who ARE very fit always receive high scores and those who are less fit get lower scores. This means that it is an accurate fitness test. A second thing which makes it a good test is that it is reliable. By this it means that if a person takes the test twice (say about a week apart) he or she will get almost the same score both times.

UNDERSTANDING THE MAXIMUM OXYGEN UPTAKE TEST

To understand how the maximum oxygen uptake test works you have to know something about how the body gets the energy it needs to make the muscles work.

Some of you, especially if you have done biology, will know a lot of this material already. If you do, that's great. If you don't then work your way through and try answering the questions at the end of each section. If you get the answers right continue on, if you don't then go over the material again. If you still have need of help after that, see your teacher.

This booklet is divided into two sections:

i. The biological background to the maximum oxygen uptake test.

ii. The maximum oxygen uptake test- How it is performed & how the scores are calculated.

Part One

HOW THE LUNGS WORK

We are all surrounded by air all of our lives. The air is made up of several different gases. These are:

O_2 Oxygen

N Nitrogen

CO_2 Carbondioxide

The inhaled nitrogen and carbondioxide are not used by the body and are therefore of little importance.

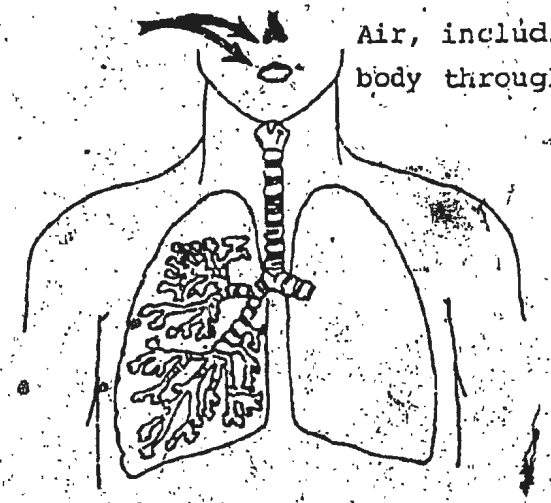
It is the OXYGEN that is very important and which keeps us alive. The function of the lungs is

TO EXTRACT OXYGEN FROM THE AIR

The oxygen which is extracted (that means taken out of) the air is used by the body to keep us alive.

Getting the Air into the lungs

When we breathe in we suck air (containing O_2 N_2 & CO_2) into the lungs. This is called inspiration.



Air, including oxygen, enters the body through the nose or mouth

Breathing out is called expiration.

QUESTIONS

Now that you have looked at the diagram see if you can answer the following questions:

1. How does air enter the body? Through the _____ and _____.

2. What is the chemical symbol for:

   a. Oxygen ..... _____
   b. Nitrogen ..... _____
   c. Carbondioxide ..... _____

3. The function of the lungs is to _____ oxygen from the air.

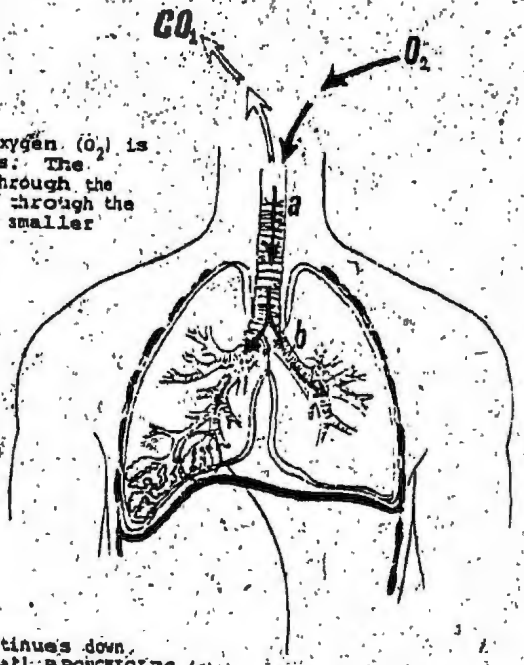
4. Do we use nitrogen in our bodies? Yes No
   Do we use carbondioxide in our bodies Yes No
   Do we use oxygen in our bodies Yes No

Now turn the page upside down and check your answers. If you have any wrong turn back to the previous page. If you still have trouble see your teacher.

Answers

1. Nose/mouth 2. O_2, N & CO_2 3. Extract 4. No, No, Yes

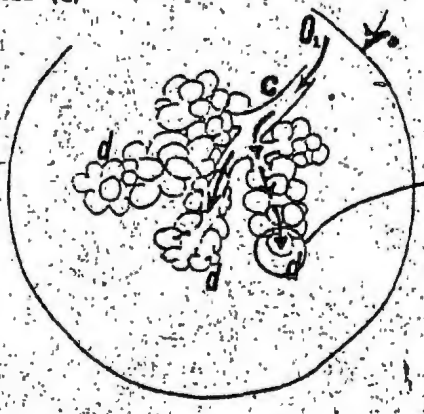
Getting OXYGEN into the blood

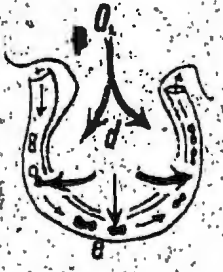


1 Air, containing oxygen (O_2) is sucked into the lungs. The oxygen passes down through the TRACHEA (a) and then through the BRONCHUS (b) into the smaller tubes of the lungs.

a. TRACHEA
b BRONCHUS
c BRONCHIOLES
d ALVEOLI
e CAPILLARY

2 The oxygen continues down through the small BRONCHIOLES (c) and then reaches the air sacs or ALVEOLI (d)



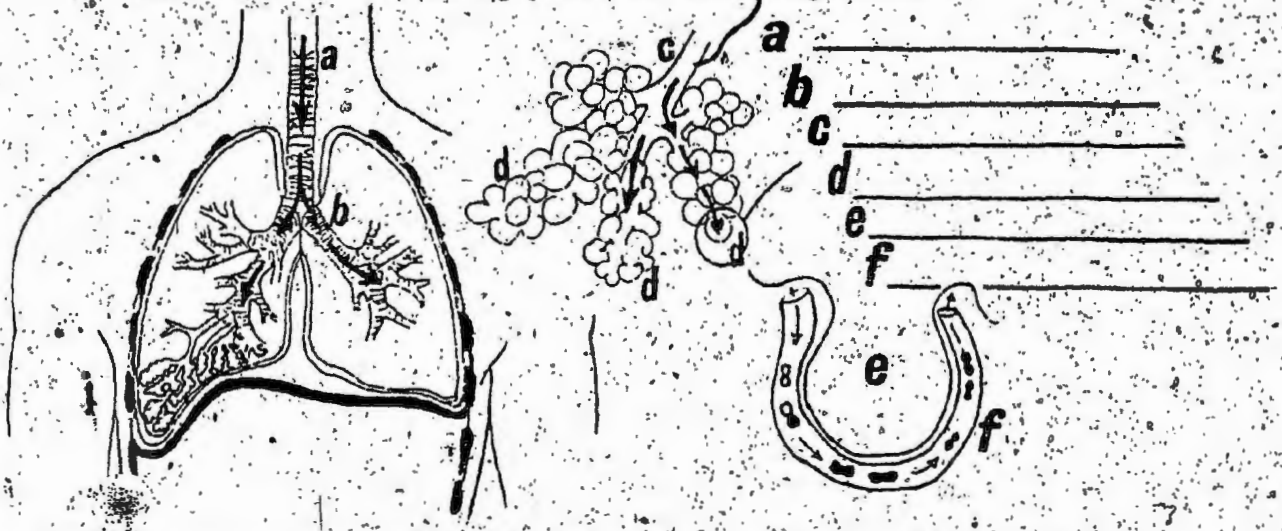


3 The oxygen passes through the wall of the alveoli; through the wall of the CAPILLARY (e) and into the blood flowing through the capillary.

QUESTIONS

Now that you have looked at the diagram see if you can answer the following questions:

1. What are the following parts of the lung called?



a _____

b _____

c _____

d _____

e _____

f _____

2. The oxygen goes through the wall of the alveoli and into the _____

3. The blood flows through _____.

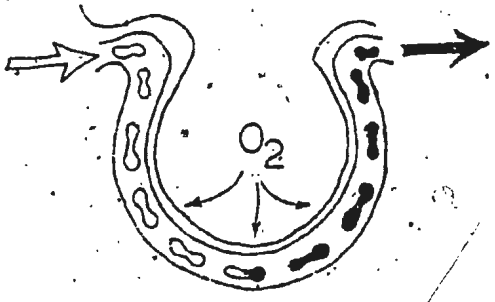
Now turn the page upside down and check your answers. If you have any wrong turn back to the diagram on the previous page. If you still have trouble see your teacher.

Answers

1. a-trachea, b-bronchus, c-bronchiole, d-alveoli, e-alveoli, f-capillary. 2. Capillary or blood. 3. Capillary

How BLOOD carries OXYGEN

1 THE OXYGEN GOES THROUGH THE WALL OF THE ALVEOLI AND INTO THE BLOOD WHERE IT IS CARRIED BY THE RED BLOOD CELLS (R.B.C'S)

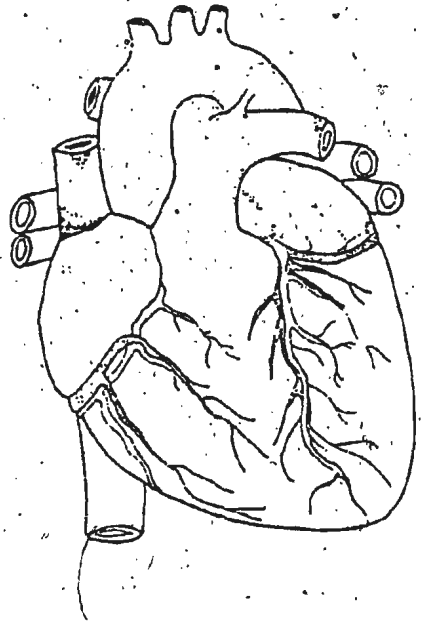


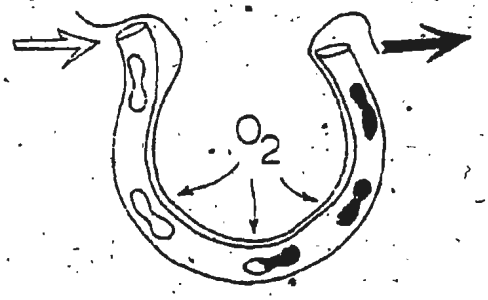
2 THE RED BLOOD CELLS ARE DISC SHAPED, THINNER IN THE MIDDLE THAN AT THE EDGES

RED BLOOD CELL CARRYING OXYGEN

RED BLOOD CELL NOT CARRYING OXYGEN

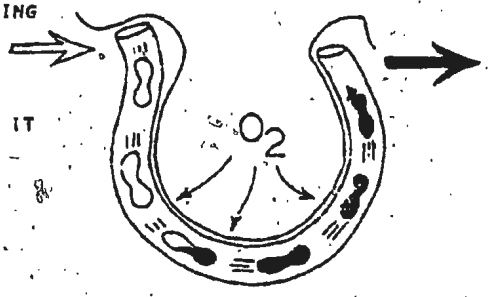
3 THE HEART PUMPS THE BLOOD, WITH THE OXYGEN CARRYING R.B.C'S, THROUGHOUT THE BODY. THE HARDER AND FASTER THE HEART PUMPS, THE FASTER THE BLOOD FLOWS THROUGH THE LUNGS AND THE REST OF THE BODY





4 THE BLOOD ENTERS THE LUNGS CARRYING LITTLE OXYGEN AND LEAVES FULL OF OXYGEN

IT LEAVES FULL OF OXYGEN EVEN IF IT PASSES THROUGH THE LUNGS AT TOP SPEED



5 REGARDLESS OF HOW FIT YOU ARE AND HOW FAST THE BLOOD FLOWS THROUGH THE LUNGS THE BLOOD ALWAYS LEAVES FULL OF OXYGEN

QUESTIONS

Now that you have looked at the diagram see if you can answer the following questions.

1. What do the letters R.B.C. stand for.

2. Draw a top view and a side view of a red blood cell.

3. The blood arrives at the alveoli containing _____ oxygen.

4. If the blood is flowing through the alveoli at full speed it leaves _____ of oxygen.

5. The _____ pumps the blood around the body.

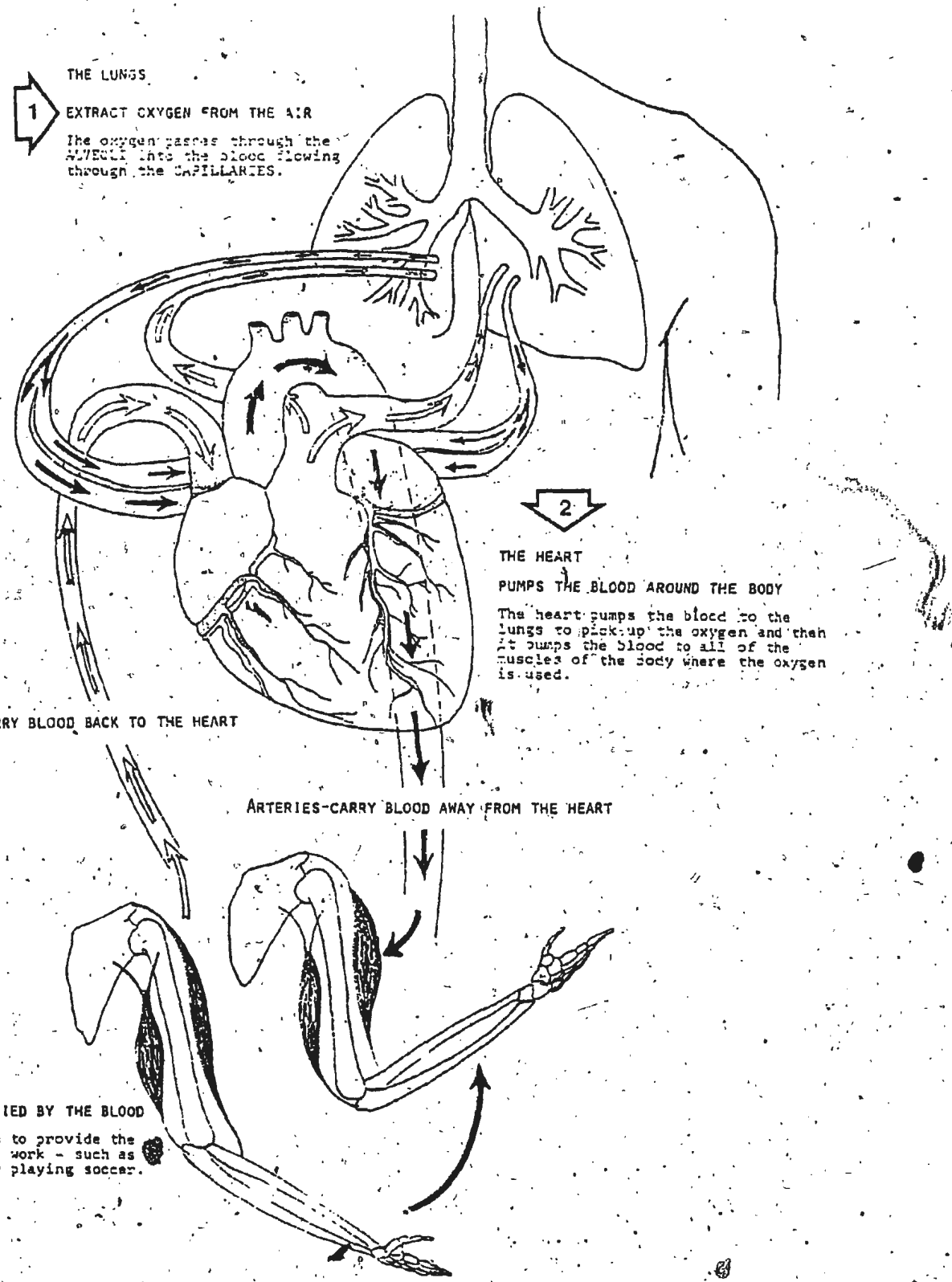
6. The harder and faster the heart beats, the _____ the blood flows around the body and through the lungs.

Now turn the page upside down and see if you had the correct answers. If not turn back to the diagram and go over it again. If you still have trouble see your teacher.

Answers

1. Red blood cell. 2. Top view. ⊙ side view ⬭ 3. Little
4. Full. 5. Heart. 6. Faster.

Getting OXYGEN to the MUSCLES



1 THE LUNGS

EXTRACT OXYGEN FROM THE AIR

The oxygen passes through the ALVEOLI into the blood flowing through the CAPILLARIES.

2

THE HEART

PUMPS THE BLOOD AROUND THE BODY

The heart pumps the blood to the lungs to pick up the oxygen and then it pumps the blood to all of the muscles of the body where the oxygen is used.

VEINS-CARRY BLOOD BACK TO THE HEART

ARTERIES-CARRY BLOOD AWAY FROM THE HEART

3

THE MUSCLES

USE THE OXYGEN CARRIED BY THE BLOOD

They use the oxygen to provide the energy needed to do work - such as lifting, running or playing soccer.

QUESTIONS

Now that you have looked at the diagram see if you can answer the following questions:

1. The _____ pumps the blood around the body.
2. The heart pumps blood to the _____ to pick up oxygen and to the muscles where the oxygen is used to provide _____.
3. Arteries carry blood _____ the heart.
4. Veins carry blood _____ the heart.
5. .

Now turn the page upside down and check your answers. If you have any wrong turn back to the diagram and go over it again. If you still have trouble then see your teacher.

Answers

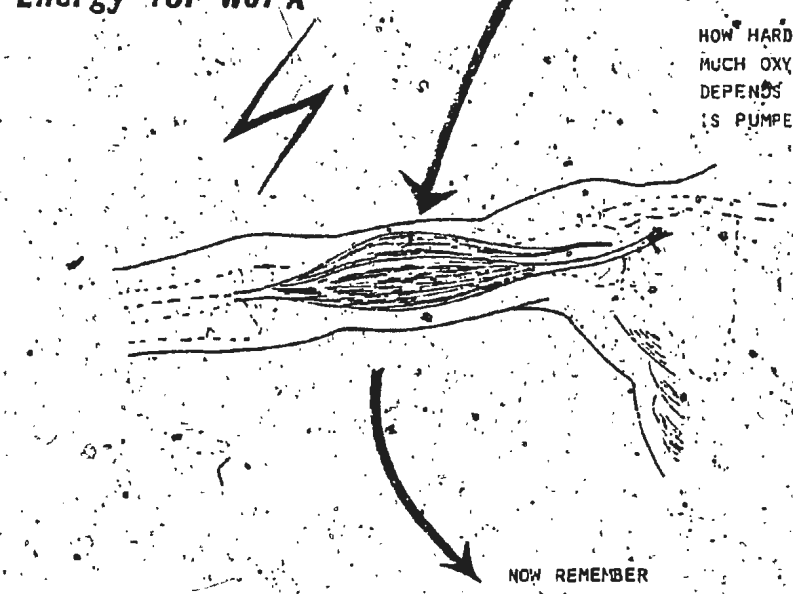
1. Heart. 2. lungs. energy. 3. Away from. 4. Towards.

USING the OXYGEN

1. FOR A MUSCLE TO WORK IT NEEDS TWO THINGS:-
   (A) FOOD - USUALLY A SUGAR CALLED GLUCOSE
   (B) OXYGEN.

THE MUSCLE CONTAINS ENOUGH GLUCOSE TO WORK HARD FOR A LONG TIME

HOW HARD IT DOES WORK DEPENDS ON HOW MUCH OXYGEN THE MUSCLE CAN GET. THIS DEPENDS ON HOW MUCH OXYGEN RICH BLOOD IS PUMPED TO IT.



NOW REMEMBER

2. A. THE BLOOD LEAVING THE LUNGS IS ALWAYS FULL OF OXYGEN
   B. THE MUSCLES WILL USE ALL OF THE OXYGEN THEY CAN GET WHEN THEY ARE WORKING HARD
   C. HOW HARD THE MUSCLE IS ABLE TO WORK DEPENDS ON HOW MUCH BLOOD THE HEART CAN PUMP TO THE MUSCLES.
   D. THE MORE BLOOD THAT IS PUMPED TO THE MUSCLES THE MORE OXYGEN THE BODY USES.

3. HOW MUCH OXYGEN CAN BE USED IS A MEASURE OF HOW MUCH BLOOD THE HEART CAN PUMP. THIS IN TURN IS THE BEST MEASURE OF A PERSON'S FITNESS. TO MEASURE FITNESS THIS WAY THE MAXIMUM AMOUNT OF OXYGEN WHICH A PERSON CAN USE IN ONE MINUTE IS FOUND.

THE MAXIMUM AMOUNT OF OXYGEN THAT THE BODY CAN USE IN ONE MINUTE IS CALLED

MAXIMUM OXYGEN UPTAKE

QUESTIONS

Now that you have looked at the diagram see if you can answer the questions.

1. To do work the muscles need. a. _____

   b. _____

2. How hard the muscles are able to work depends on how much _____ they can get.

3. How much oxygen the body can use is a measure of how much _____ the heart can pump.

4. The amount of blood that the heart can pump in a minute is a measure of a person's _____.

5. The amount of oxygen the body can use in one minute is called _____.

Now turn the page upside down and check the answers. If you have any wrong turn back to the previous diagram and go over it again. If you are still having trouble see your teacher.

Answers

1. Food (or glucose) and oxygen. 2. Oxygen. 3. Blood. 4. Fitness
5. Maximum oxygen uptake.

Part Two

The Maximum Oxygen Uptake Test

A test of maximum oxygen uptake is used to measure fitness. It is called the maximum oxygen uptake test. The score that a person gets on the test is called his or her

Max. $\dot{V}O_2$

The maximum oxygen uptake test measures the amount of oxygen that a person is able to use when they are working as hard as possible. It is a good measure of fitness because it directly measures how hard the person is able to work his muscles.

How do we do a maximum oxygen uptake test? Let us look at the procedure.

STEP ONE

Get all the equipment together that will be needed. The equipment required is:

1. A BICYCLE ERGOMETER. This is a piece of equipment which is like an exercise bike. It has a saddle and peddles like a normal bike but when the peddles are turned instead of going along the bike stays still and a large, heavy, wheel is turned. There is a brake on the wheel which can be tightened to make it harder and harder for the person to peddle. In this way it is possible to control just how much work a person does.

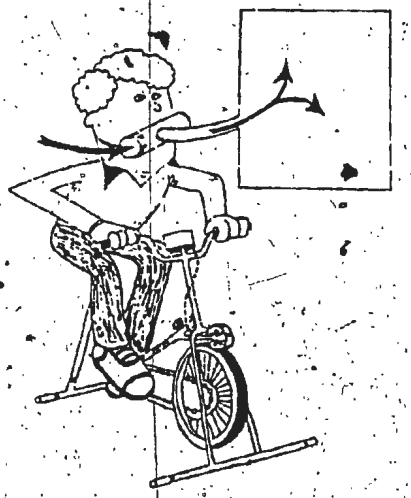
2. DOUGLAS BAGS. These are just large bags in which all of the air that a person expires is collected. To collect the gas the person breathes in and out through a mouth-piece which allows the outside air to be breathed in but which makes all of the expired air go into the collection bag.

3. AN OXYGEN ANALYSER. This is a piece of equipment which measures how much oxygen there is in a sample of air. If we put ordinary air into it we get a reading of about 21%. If we put expired air into it we get a reading somewhere between 12% and 18%. This instrument allows us to measure how much of the inspired oxygen has been used. If the inspired air has the normal 21% oxygen and the expired air has 16% oxygen then the person being measured has used 5%. In general the harder a person is working the more oxygen they will use and the lower the percentage of oxygen in their expired air.

4. A GAS MEASURER. This instrument measures how much gas is collected in the Douglas bags. The amount of gas is measured in millilitres which is abreviated ml.

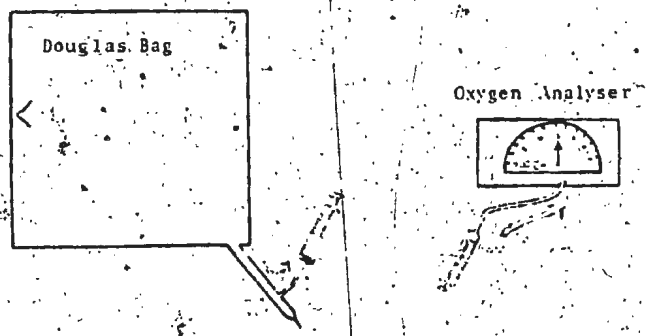
STEP TWO

The person rides the bicycle ergometer and every minute the brake is tightened so that he has to work harder. Just before he collapses from exhaustion the air that he expires is collected for ONE MINUTE. It is often difficult to judge exactly when a person approches exhaustion. Sometimes the expired gas is collected every minute until the person stops.



STEP THREE

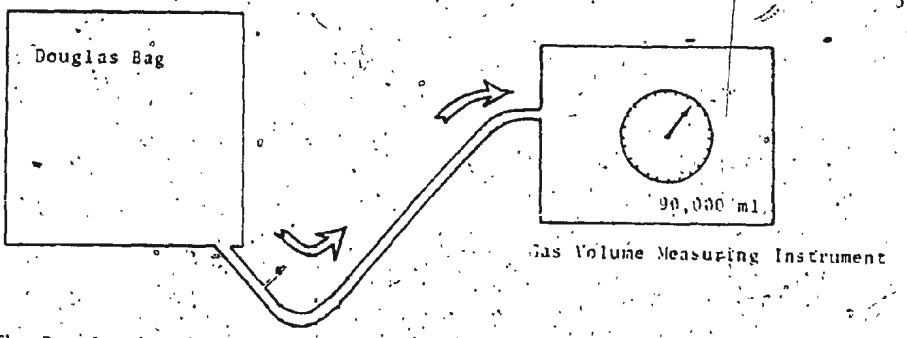
A small sample of the expired air is taken from the DOUGLAS bag and is put into the oxygen analyser. A measurement is taken from the scale of the analyser. The measurement is usually between 12 and 18%. For an example of how the calculations are done let us say that the measurement was 16%.



A small sample of expired air is taken from the Douglas Bag and is put into the oxygen analyser. This measures the percentage of oxygen in the expired air.

STEP FOUR

The expired air is then forced through the gas measurer and the volume of the expired air is measured. As an example let us say that the person expired 90,000 ml of air.



The Douglas bag is rolled up to force the expired air through the measuring instrument.

STEP FIVE

Calculate how much oxygen the subject breathed in.

To do this we use the following formula.

VOLUME OF O_2 BREATHED IN = (Volume of expired gas) x 21%*

*this is because the air that is breathed in contains 21% oxygen.

For our example this is

VOLUME OF O_2 BREATHED IN = $90{,}000 \times \frac{21}{100}$

= 18900 ml of oxygen.

This is the amount of oxygen breathed in during one minute.

STEP SIX

calculate how much oxygen the subject breathed out during the minute that the gas was collected. To do this we use the formula:

VOLUME OF O_2 BREATHED OUT = (Volume of expired air) x (the percentage of oxygen in the expired air)

For our example this is

VOLUME OF O_2 BREATHED OUT = 90,000 x 16%

$$= 90{,}000 \times \frac{16}{100}$$

= 14400 ml of oxygen.

STEP SEVEN

Calculate the amount of oxygen used in the minute that the gas was collected.

OXYGEN USED = (OXYGEN BREATHED IN — OXYGEN BREATHED OUT)

for our example this is

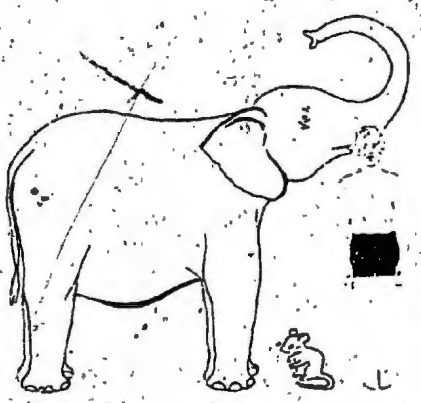
OXYGEN USED = 18900 — 14400

= 4500 ml of oxygen in one minute

= 4500 ml O_2/min.

STEP EIGHT

Different size animals need different amounts of oxygen to do the same amount of work.



Because of this there is a need to adjust the maximum oxygen uptake score to reflect the different sizes of the people who are tested. The easiest way to do this is to work out how much oxygen was used during the minute by every kilogram of the subjects body. To do this the subject is weighed and the amount of oxygen he used is divided by his weight in kilograms.

$$\text{Max. } \dot{V}O_2 = \frac{\text{(amount of oxygen used in one minute)}}{\text{weight of the subject}}$$

for our example: if the subject weighs 73 Kg

$$\text{Max. } \dot{V}O_2 = \frac{4500 \text{ ml } O_2/\text{min}}{73 \text{ kg}}$$

$$= 61.64 \text{ ml } O_2/\text{kg/min}$$

SUMMARY OF STEPS

1. COLLECT ALL OF THE EQUIPMENT

2. WORK THE SUBJECT TO EXHAUSTION, COLLECT EXPIRED AIR FOR ONE MINUTE.

3. TAKE A SAMPLE OF THE EXPIRED AIR AND MEASURE HOW MUCH OXYGEN IT CONTAINS

4. MEASURE HOW MUCH AIR WAS EXPIRED IN THE ONE MINUTE.

5. CALCULATE HOW MUCH OXYGEN THE SUBJECT BREATHED IN DURING THE ONE MINUTE.

6. CALCULATE HOW MUCH OXYGEN THE SUBJECT BREATHED OUT IN THE ONE MINUTE.

7. CALCULATE HOW MUCH OXYGEN THE SUBJECT USED IN THE ONE MINUTE.

8. WEIGH THE SUBJECT. DIVIDE THE AMOUNT OF OXYGEN USED IN THE ONE MINUTE BY THE WEIGHT OF THE SUBJECT.

   RESULT GIVES **Max. $\dot{V}O_2$** IN ml of O_2/min/kg.

9. REMEMBER - THE EXPIRED AIR IS COLLECTED DURING THE **Last** MINUTE OF EXERCISE. *ΔΔΔ

A SAMPLE CALCULATION

To calculate a Max. VO_2 score there are FOUR things which you need to know.

1. Volume of expired air for one minute's exercise. In the formula this is called VE.
   e.g. 60,000 ml
2. The percentage of oxygen in the INSPIRED AIR. Called %-Insp.
   e.g. 21%
3. The percentage of oxygen in the EXPIRED AIR. Called %-Exp.
   e.g. 17%
4. The weight of the person in kilograms. Called wt.
   e.g. 63kg.

THE FORMULA

$$\text{Max. } VO_2 = \frac{\left(\frac{VE \times \%\text{-Insp}}{100}\right)\left(\frac{VE \times \%\text{-Exp}}{100}\right)}{wt}$$

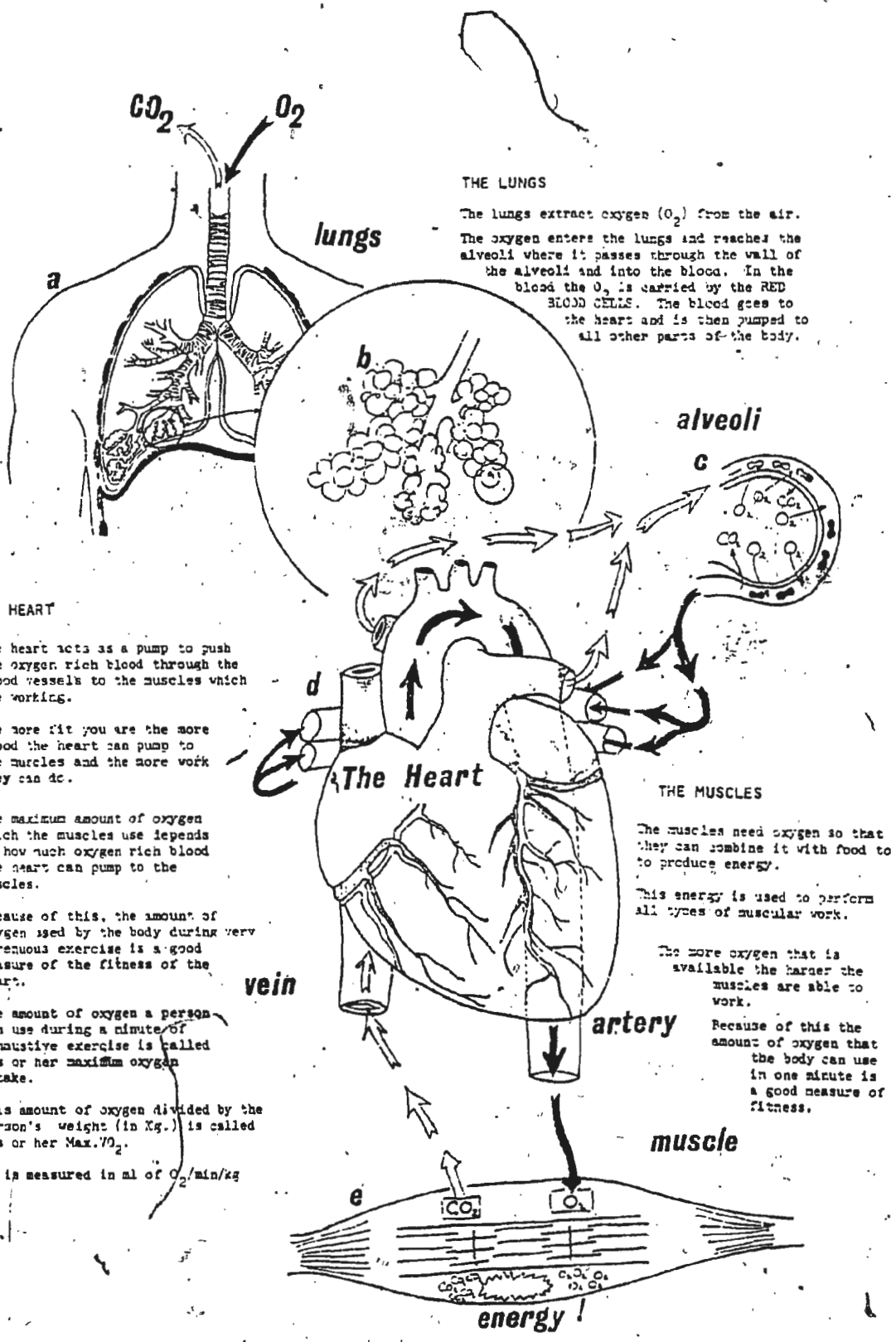
USING THE FIGURES ABOVE

$$\text{Max. } VO_2 = \frac{\left(\frac{60\,000 \cdot 21}{100}\right) - \left(\frac{60000 \cdot 17}{100}\right)}{63}$$

$$= \frac{12600 - 10200}{63}$$

$$= 38.1 \text{ ml.} O_2/\text{kg/min}$$

THE WHOLE SYSTEM



THE LUNGS

The lungs extract oxygen (O_2) from the air.

The oxygen enters the lungs and reaches the alveoli where it passes through the wall of the alveoli and into the blood. In the blood the O_2 is carried by the RED BLOOD CELLS. The blood goes to the heart and is then pumped to all other parts of the body.

THE HEART

The heart acts as a pump to push the oxygen rich blood through the blood vessels to the muscles which are working.

The more fit you are the more blood the heart can pump to the muscles and the more work they can do.

The maximum amount of oxygen which the muscles use depends on how much oxygen rich blood the heart can pump to the muscles.

Because of this, the amount of oxygen used by the body during very strenuous exercise is a good measure of the fitness of the heart.

The amount of oxygen a person can use during a minute of exhaustive exercise is called his or her maximum oxygen uptake.

This amount of oxygen divided by the person's weight (in Kg.) is called his or her Max.VO_2.

It is measured in ml of O_2/min/kg

THE MUSCLES

The muscles need oxygen so that they can combine it with food to to produce energy.

This energy is used to perform all types of muscular work.

The more oxygen that is available the harder the muscles are able to work.

Because of this the amount of oxygen that the body can use in one minute is a good measure of fitness.

USING FITNESS SCORES

Fitness scores are of great use in a fitness program as they allow a person to measure the effectivness of a long term series of exercises.

For example let us look at the scores of a student. Bill G. was tested for his Max. VO_2 at the start of the school year.

His scores were:

i. In one minute he expired 87,000 ml of gas.
ii. Inspired air contained 21% oxygen.
iii. Expired air contained 18% oxygen.
iv. His weight was 62 kg.

CALCULATE HIS Max. VO_2.

Bill's starting Max. VO_2 was..... _____ ml. O_2/kg/min

At the end of 12 weeks of regular jogging he was tested again. This time his scores were:

i. In one minute he expired 85,000 ml of gas.
ii. Inspired air contained 21% oxygen.
iii. Expired air contained 16% oxygen.
iv. His weight was 60 kg.

CALCULATE HIS NEW Max. VO_2.

Bill's final Max. VO_2 was ..... _____ ml. O_2/kg/min

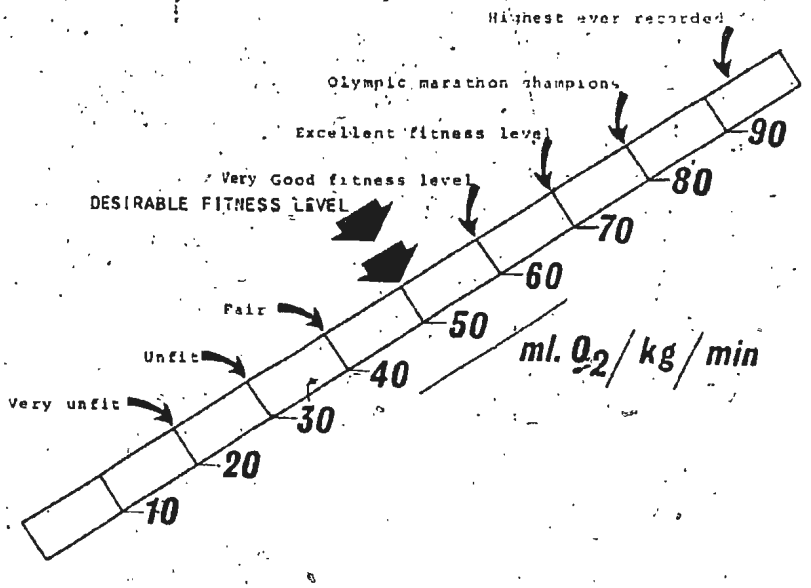
Check your Max. VO_2 scores, they are printed at the bottom of the next page.

As you can see, Bill improved his fitness over the twelve week period. By regularly retesting it will be possible for Bill to MEASURE if he is getting fitter, or less fit.

INTERPRETING FITNESS SCORES

Over a twelve week period Bill increased his Max. VO_2 from 42.1 to 56.6 ml. O_2/kg/min. What does this mean in terms of how fit he is? How does he compare with other people?

The chart below shows the kind of scores which have been recorded by different groups of people.



As you can see, Bill went from a level of fitness which would be described as FAIR to having a desirable level of fitness.

First Fitness score = 42.1, final score 56.6 ml. O_2/kg/min.

Some Problems

Although the MAXIMUM OXYGEN UPTAKE TEST is the best way to measure a person's fitness it does have a few problems. For one thing it is very hard work and not many people are willing to work until they are exhausted and if they give up before they are exhausted they do not get as high a score as they should.

Then there is the problem of all of the expensive equipment that is needed to measure the percentage of oxygen in the air, and lastly there is the problem that for some people a Max. VO_2 test can be dangerous. At least one person has died during the test because they had a weak heart which could not stand the strain. Because of this anyone doing a test to exhaustion should have a complete medical examination before they start.

Because of these problems some other tests have been invented in which AN ESTIMATE of maximum oxygen uptake is made from a person's score on a non-exhaustive test. These tests are called sub-maximal tests.

The best of these sub-maximal tests is the ASTRAND bicycle ergometer test.

In the Astrand bicycle ergometer test the brake on the ergometer is set at a certain level, usually between 1½ and 5 kpm. The rider peddles with 50 revolutions per minute for about 4 minutes. During the last minute of the ride the persons heart rate (pulse rate) is taken.

The chart on the next page is used to calculate the maximum oxygen uptake.

TO USE THE CHART. Place a straight edge on the line on the right of the page at the level which is the same as the reading of the bicycle ergometer brake.

Place the other end of the straight edge on the line to the left at the level of the pulse rate which was recorded.

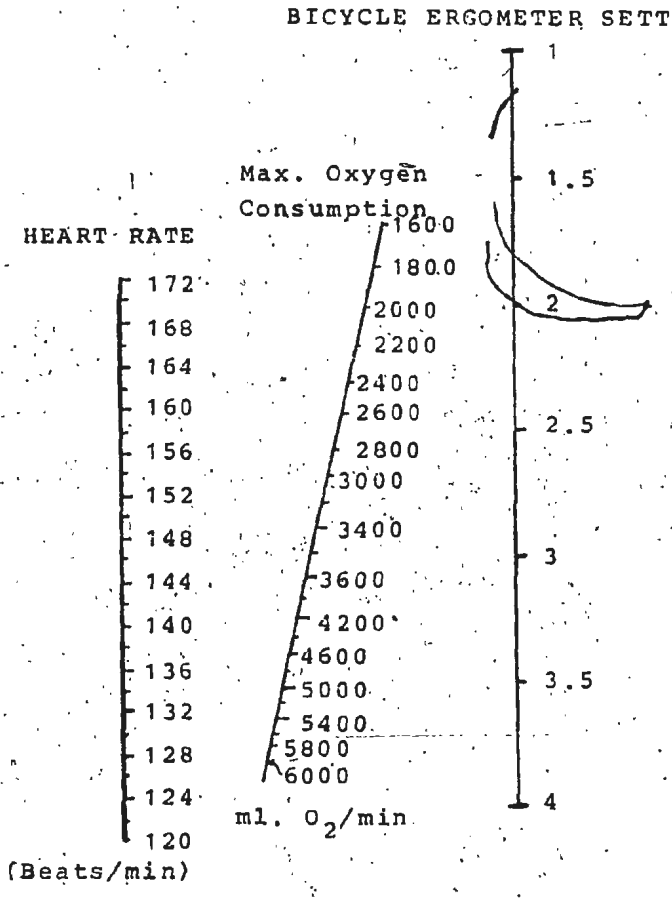
Where the straight edge cuts the MAXIMUM OXYGEN UPTAKE line read off the amount of oxygen which the person COULD USE if they worked to exhaustion.

(Many people find it easier to use the BOTTOM edge of a ruler to read off the maximum oxygen uptake rather than the top edge.)

REMEMBER

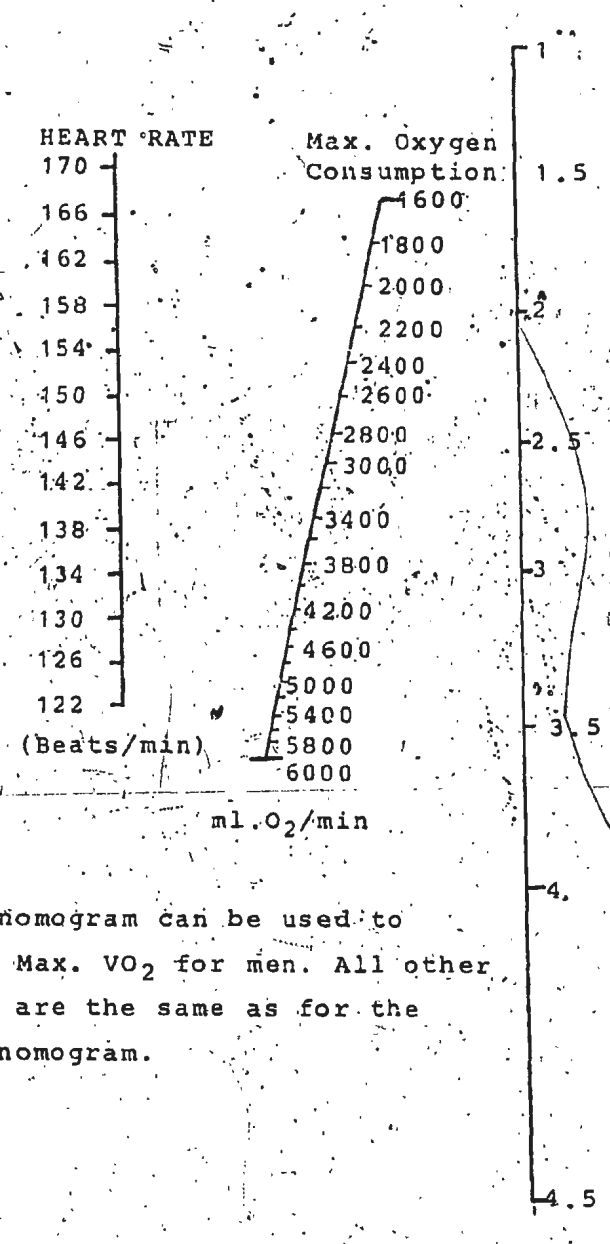
1. The amount of oxygen must be divided by the person's weight to get a Max. VO_2 score.
2. There are separate charts for males and females.

Female



**This Nomogram can be used to predict Max. VO_2 for women. It is to be used with a MONARCH bicycle ergometer on which the rider peddles at 50 revolutions/min. The pulse rate is to be taken after the rider has been working for FOUR (4) minutes. The "oxygen used" shows the amount of oxygen used by the rider in ONE MINUTE, IF THEY WERE WORKING AT THEIR MAXIMUM. To calculate the Max. VO_2, that amount of oxygen should be divided by the rider's body weight in kg. This will give the rider's maximum oxygen uptake in ml O_2/kg/min.

Male



**This nomogram can be used to predict Max. VO_2 for men. All other details are the same as for the women's nomogram.

If there is no bicycle ergometer available there are other, less accurate, methods of measuring fitness.

Some of the more common fitness tests which are used in schools are:

a. The Canada Home Fitness Test.
b. The Cooper 12 minute run.
c. The Harvard Step Test.

These, and many others, are good tests of fitness. However, none of them is as accurate as either the complete maximum oxygen uptake test or the Astrand estimate of maximum oxygen uptake.

APPENDIX A

These were the objectives which the instructional package was designed to meet. Also included are the questions which were used to test the objectives.

Behavioural Objectives

All behavioural objectives were constructed such that they were suitable for testing using pencil and paper tests. The five sub-sets of objectives represent one sub-set for each of the sub-packages with one sub-set for the overall instructional package.

Sub-set I

a-h. That given a diagram of the heart and lungs along with the names of the anatomical parts the student will be able to match the names of the parts with 80% accuracy. The parts concerned were: a-heart, b-veins, c-arteries, d-trachea, e-bronchus, f-bronchiole, g-alveoli and h-capillary.

j-z. That in an objective test the student will be able to correctly answer 80% of the questions covering the following material.

j. The function of the lungs is to extract oxygen from the air.

k. That the oxygen passes through the walls of the lungs and into the capillary (blood).

l. That the blood entering the lungs contains very little oxygen.

m. That the blood leaving the lungs is full of oxygen.

n. That however fast the blood flows through the lungs it leaves full of oxygen.

o. That muscles need food and oxygen to produce energy.

p. That the harder a person works the more oxygen he uses.

q. That if the muscles do not get the oxygen they need they are forced to stop working.

r. That the heart pumps oxygen rich blood to the muscles.

s. That how much blood the heart is able to pump will determine how hard a person can work.

t. That there is a limit to how much oxygen rich blood the heart is able to pump per minute.

u. That the amount of oxygen rich blood which arrives at the muscles determines how much work a person can do.

v. That the maximum amount of oxygen a person can use per minute is a measure of how fit he is.

w. That the maximum amount of oxygen a person can use is called his maximum oxygen uptake.

x. That different size people need different amounts of oxygen to do the same amount of work.

y. That to get a Max. VO_2 score the amount of oxygen used in a minute is divided by the subject's weight.

z. That Max. VO_2 is measured in ml. O_2/kg/min.

Sub-set II

a. That given a list of all of the steps in the performance of a maximum oxygen uptake test the student will be able to place them in the correct order.

b. That the student will be able to identify the four essential measurements which must be made to obtain a Max. VO_2 score.

c. That the student will identify that Max. VO_2 measurements are made in the last minute of strenuous exercise.

Sub-set III

a. That given the amount of gas exhaled per minute, the percentage of oxygen in that gas, the oxygen content

of inspired air and the weight of the subject, the student will be able to calculate a Max. VO_2 score. The formula for the calculation will be given.

Sub-set IV

a. That given a set of Max. VO_2 scores the student will be able to place them in catagories of excellent, desirable, fair and poor fitness levels with 80% accuracy.

Sub-set V

a. That the student will be able to state that the maximum oxygen uptake test is the best available measure of physical fitness.

b. That the maximum oxygen uptake test is a measure of how well the body can extract oxygen from the air.

c. That the maximum oxygen uptake test is a measure of the hearts ability to pump blood.

d. That most other fitness tests are only estimates of maximum oxygen uptake.

e. That the maximum oxygen uptake test is a very strenuous test that should only be performed after the subject has had a medical examination.

f. That Max. VO_2 scores can be improved by training. *

* N.B. All objectives are refered to by their sub-section Roman numberal and by their letter. That is V_f.

Test Items

Objective Tested.	Question Number	
I-j	1	The major function of the lungs is to extract oxygen from the _____.
I-k	2	The oxygen is able to pass through the wall of the alveoli into the _____.
I-l.m.n.	3	However fast blood flows through the lungs it always arrives containing _____ oxygen and leaves containing _____ oxygen.
I-o	4	To produce energy muscles need _____ and _____.
I-q	5	Usually when a muscle stops working it is because it does not have enough _____.
I-r	6	The _____ pumps oxygen rich blood to the muscles.
I-s.u.	7	How much work a person can do depends on how much _____ _____ blood arrives at the muscles.
I-v	8	How much oxygen can be used by the body and how much oxygen rich blood the _____ can pump, is a measure of _____.
I-w	9	The maximum amount of oxygen that a person can use in one minute is called his /her _____.
I-x.y.	10	To get a Max. VO_2 score, the amount of oxygen used per minute is divided by the person's _____.
I-z	11	Which of the following is a Max. VO_2 score? a. 23 ml. O_2/kg/min b. 199 litres/kg/min c. 29 lbs.O_2/hr/m d. 106 cu.in/ml.

Objective Tested	Question number	
II-a	12	The following is a list of steps required to obtain a Max. VO2 score. Read the list and then place the steps in the correct order. Put a 1 beside the first step, 2 beside the second step, etc.

___ Calculate how much oxygen the subject used in one minute.

___ Calculate how much oxygen the subject breathed in, in one minute.

___ Work the subject to exhaustion, collect the expired air for one minute.

___ Collect all of the equipment together.

___ Measure how much air was expired in one minute.

___ Weigh the subject. Divide the amount of oxygen used in one minute by the weight of the subject.

___ Calculate the amount of oxygen the subject breathed out in one minute.

___ Take a sample of the expired air and measure how much O_2 it contained.

II-b	13	Below is a list of eight measurements only FOUR of which are required to calculate a Max. VO_2 score. Place a cross through the letter in front of the four which are required.

a. Height
b. Weight
c. Sex
d. Age

Objective Tested	Question number	
	13 (cont.)	e. Percentage of oxygen in air f. Percentage of oxygen in expired air. g. Volume of air expired. h. Volume of oxygen in blood.
II-c	14	Measurement of Max. VO_2 should be made a. Immediately after the person stops exercising. b. One minute after the person stops exercising c. One minute before the person stops exercising.
III-a	15	Calculate the Max. VO_2 score for the following person. He exhales 100,000 ml of oxygen in one minute. The INHALED air contained 21% oxygen and the EXHALED gas contained 15% oxygen. The person weighs 100 Kg. N.B The formula is given. Max. VO_2 = _____ ml. O_2/kg/min.
IV-a	16	On a Max. VO_2 test people get these scores: Bob-82, Bill-91, Chris-55 Ron-29, Eric-36 and John-63. Describe them as exceptionally fit, very fit desirable fit, fair fitness or low fitness. Bill is _____ Bob is _____ Chris is _____ Ron is _____ Eric is _____ John is _____

Objective Tested	Question number	
V-a	17	The Max. VO_2 test is the most _____ test of physical fitness.
I-p	18	The harder a person works the _____ oxygen he uses.
I-t V-c	19	Up to a limit, the harder a person works the more _____ blood the heart pumps per minute.
V-b	20	The Max. VO_2 test is a measure of how well the body can extract _____ from the _____.
V-e	21	The Max. VO_2 test is very _____ and should only be performed after the subject has had a _____ examination.
V-d	22	Other fitness tests give an _____ of maximum oxygen uptake.
V-f	23	A person who takes a Max. VO_2 test and then trains hard for three months would expect a _____ score at the end of the training period.
I a-h	24-31	See diagrams on following page.

APPENDIX B

Suggestions for follow up activities.

SUGGESTED FOLLOW UP ACTIVITIES

1. Test the class on two different fitness tests. Compare the results. Are the same people 'fit' or 'unfit' on both tests? If the results are not id identical discuss which of the tests is likely to have given the best results.

2. Measure the fitness of a group of students on one of the fitness tests. Record the results and then re-test the students several weeks later. If this is done in conjunction with a fitness unit it can show the improvment which has been achieved. If it is done over the period of a vacation it may show some deterioration.

3. Have the students investigate as many other fitness tests as possible.

4. Have the students prepare reports on the following topics.
   a. Fitness scores of credit and non-credit programme students.
   b. Fitness levels of males and females.
   c. Fitness levels of varsity players as compared to intra-mural players.

5. Encourage the students to undertake a long-term periodic testing programme.

APPENDIX C

List of related references.

Without a doubt the finest current text book is,

Astrand, P.O. & Rodahl, K. Textbook of Work Physiology - physiological bases of exercise, McGraw-Hill Book Co. New York; 1977.

Articles of interest are listed on the following pages in alphabetical order.

1 Asmussen, E. and I. Hemmingsen, "Determination of maximum working capacity at different ages in work with legs or with the arms," Scandavian Journal of Clinical Laboratory Investment. 10. 67-71, 1958.

2 Astrand, P.O. "Experimental Studies of Physical Working Capacity in Relation to Sex and Age," Copenhagen: Munksgaard, 1952.

3 Astrand, P.O. and I. Ryhming, "A nomogram for calculation of aerobic capacity (physical fitness) from pulse rate during submaximal work", Journal of Applied Physiology, 7: 218-221, 1954.

4 Astrand, P.O. and B Saltin, "Oxygen uptake during the first minutes of heavy muscular exercise", Journal of Applied Physiology, 16: 971-976, 1961.

5 Astrand, P.O. and B. Saltin, "Maximal oxygen uptake and heart rate in various types of muscular activity", Journal of Applied Physiology, 16: 977-981, 1961.

6 Binkhorst, R.A. and P. Van Leuween, "A rapid method of the determination of aerobic capacity," International Z. Angew Physiology 19: 459-467, 1963.

7 Buskirk, E. and H.L. Taylor, "Maximal oxygen intake and its relation to body composition with special reference to chronic physical activity and obesity", Journal of Applied Physiology 11: 72-78, 1957.

8 Dobeln, W, v "A simple bicycle ergometer", Journal of Applied Physiology 7: 222-224, 1954.

9 Faulkner, J.A., D.E. Roberts, R.L. Elk and J. Conway, "Cardiovascular responses to submaximum and maximum effort cycling and running", Journal of Applied Physiology 30: 457-461, 1971.

10 Glassford, R.G., et al. "Comparison of maximal oxygen uptake values determined by predicted and actual methods", Journal of Applied Physiology 20: 509-513, 1965.

11 Hermansen, L. and B Saltin, "Oxygen uptake during maximal treadmill and bicycle exercise", Journal of Applied Physiology 16: 153-156, 1961.

12 Maksud, M.G. and K.D. Coutts, "Comparison of a continuous and discontinuous graded treadmill test for maximal oxygen uptake", Medicine Science in Sports 4: 182-186, 1972.

13 McArdle, W.D. et al. "Reliability and interrelationships between maximal oxygen intake, physical work capacity and step test scores in college women". Medicine Science in Sports 4: 182-186, 1972.

14 McArdle, W.D. and J.R. Magel, "Physical work capacity and maximum oxygen uptake in treadmill and bicycle exercise", Medicine and Science in Sports 2: 118-126, 1971.

15 Michael, E.D. and S. Howath, "Physical work capacity of college women", Journal of Applied Physiology 20: 263-270, 1965.

16 Mitchell, J.B., B Sproule and C. Chapman, "The physiological meaning of the maximal oxygen intake test", Journal of Clinical Investigation 37: 538-546, 1958.

17 Newton, J.L. "The assessment of maximal oxygen intake", Journal of Sports Medicine Physical Fitness 3: 164-169, 1963.

18 Rowell, L.B. H.L. Taylor and W. Wang, "Limitations to prediction of maximal oxygen uptake", Journal of Applied Physiology 19: 919-927, 1964.

19 Taylor, H., E. Buskirk and A. Henschel, "Maximal oxygen intake as an objective measure of cardio-respiratory performance", Journal of Applied Physiology 8: 73-80, 1955.

20 Wyndham, C.H. "Submaximal tests for estimating maximum oxygen intake", Canadian Medical Association Journal 96: 736-742, 1967.

APPENDIX F

Content expert for the formative evaluation was:

Consultant in Physical Education
Department of Education
Province of Newfoundland.

Learner experts for the formative evaluation were:

i. Physical Education Supervisor
Avalon Integrated School Board
St. John's
Newfoundland.

ii. Physical Education Supervisor
Terra Nova Integrated School Board
Gander
Newfoundland

Media expert for the formative evaluation was:

Faculty member
Faculty of Education
Memorial University of Newfoundland.